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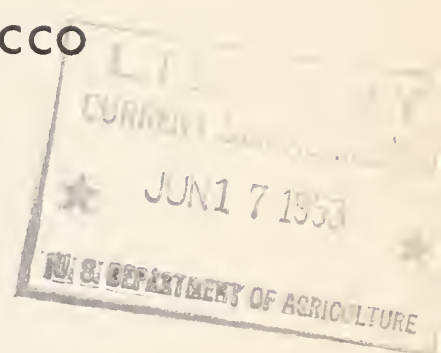
The Development of an Automatic Wood-Burning Furnace for Curing Bright-Leaf Tobacco

A Progress Report

by

Walton R. Smith, R. H. P. Miller,

O. A. Brown, & N. W. Weldon



SOUTHEASTERN FOREST EXPERIMENT STATION

Asheville, North Carolina

E. L. Demmon,

Director

U. S. Department of Agriculture - Forest Service



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THE DEVELOPMENT OF AN AUTOMATIC WOOD-BURNING FURNACE

FOR CURING BRIGHT-LEAF TOBACCO

A Progress Report

by

Walton R. Smith, R. H. P. Miller, O. A. Brown, and N. W. Weldon^{1/}

Introduction

Wood, the first fuel used to cure bright-leaf tobacco, is fast losing its importance for this purpose. While extensive research has been done on coal stokers, oil burners, automatic controls, and various types of heating equipment, very little work has been done to improve the efficiency of wood-burning furnaces for this purpose or to develop automatic controls for wood-burning furnaces. Some years ago, the Forest Utilization Service of the Southeastern Forest Experiment Station, the Forest Products Laboratory, and the Bureau of Plant Industry, Soils, and Agricultural Engineering, Division of Farm Electrification, established cooperative studies with the North Carolina Agricultural Experiment Station to conduct research on wood-burning furnaces for tobacco barns at the Tobacco Experiment Station, Oxford, North Carolina. This work has been going on since 1945 and has resulted in an entirely new type of automatic, wood-burning furnace that cures tobacco satisfactorily and at the same time saves wood and labor.

Farmers as well as foresters are interested in wood as a fuel because it offers an outlet for cull trees, limbs and tops, and various other forms of wood waste that should be removed from the woodlot. Using wood for fuel gives the farmer a chance to improve forest stands by thinnings or improvement cuttings for a profit, rather than as a management cost.

^{1/} Respectively; Technologist, Forest Utilization Service, Southeastern Forest Experiment Station, Asheville, N. C.; Engineer, Forest Products Laboratory, Madison, Wis.; Engineer, Farm Electrification Division, Bureau of Plant Industry, Soils, and Agricultural Engineering, formerly at Oxford, N. C.; Research Assistant Professor, N. C. Agricultural Experiment Station, Oxford, N. C.

In the bright-leaf tobacco belt from Virginia to Florida, there are more than a quarter million tobacco barns; some are used for as many as six cures of tobacco each summer. From the best estimates that can be obtained, each tobacco cure with a wood furnace requires from 1-1/2 to 2 cords of wood. Since wood was the fuel used in more than 80 percent of the tobacco barns in the early 40's, about 2 million cords of wood were used annually for this purpose.

Up to the present time the typical wood furnace in a tobacco barn has been little more than an open fireplace (figures 1 and 2). Actually it is either one or two fire chambers, each about 18 inches wide, 18 inches high, and 8 feet long, extending inside the barn. Large flue pipes 10 to 12 inches in diameter extending from the furnace to the far side of the barn make a U turn and leave the barn just over the furnace to form a chimney which may stop within a few feet or extend above the roof. There are numerous variations of this set-up but the principle is the same. The furnace has no draft control and the amount of heat supplied to the barn depends on a man's continuous attention to the fire; he can put on more fuel to make it hotter, or pull the fire out of the furnace if the temperature gets too high. This takes a great deal of his time night and day for the 5 days of a tobacco cure.

Since existing wood-burning furnaces require so much of the farmer's time, it is little wonder that coal stokers and oil burners with automatic control and large hopper capacity have become so popular. Tobacco farmers have been changing over to the use of these fuels very rapidly; in fact, it is currently estimated that less than half of the tobacco barns are now fired by wood. Oil burners are becoming predominant because of the lower cost of installation and the ease of operation, in spite of the high annual fuel cost.



Figure 1.--The single type wood-burning furnace in common use.



Figure 2.--The double type wood-burning furnace in common use. Constant attention to the fire is required.

Review of Experimental Work

The first experimental work was done at the Tobacco Experiment Station at Oxford, North Carolina, during the summer of 1945. It was learned that some attempts had been made to burn wood efficiently in the old-type furnaces of tobacco barns by putting a tight door on the front of the furnace with smaller draft openings that could be automatically controlled. One manufacturer had developed a plan for putting a tight-fitting door on the end of the furnace, supplemented by an L-shaped sheet metal pipe which permitted air to enter the side of the furnace (fig. 3). This air-inlet pipe extended about 4 feet above the ground level of the furnace, and had a damper in the top of it to control the amount of entering air. The damper was operated by a wafer thermostat placed inside the barn.

Two barns of tobacco were cured with this equipment, using 1.15 cords of half green sweetgum per cure. The biggest disadvantage of this furnace was its failure to hold a high temperature for any length of time without refueling. At most, only about 200 pounds of wood could be put into the furnace at one time and this would burn up in two or three hours when high temperatures were needed.

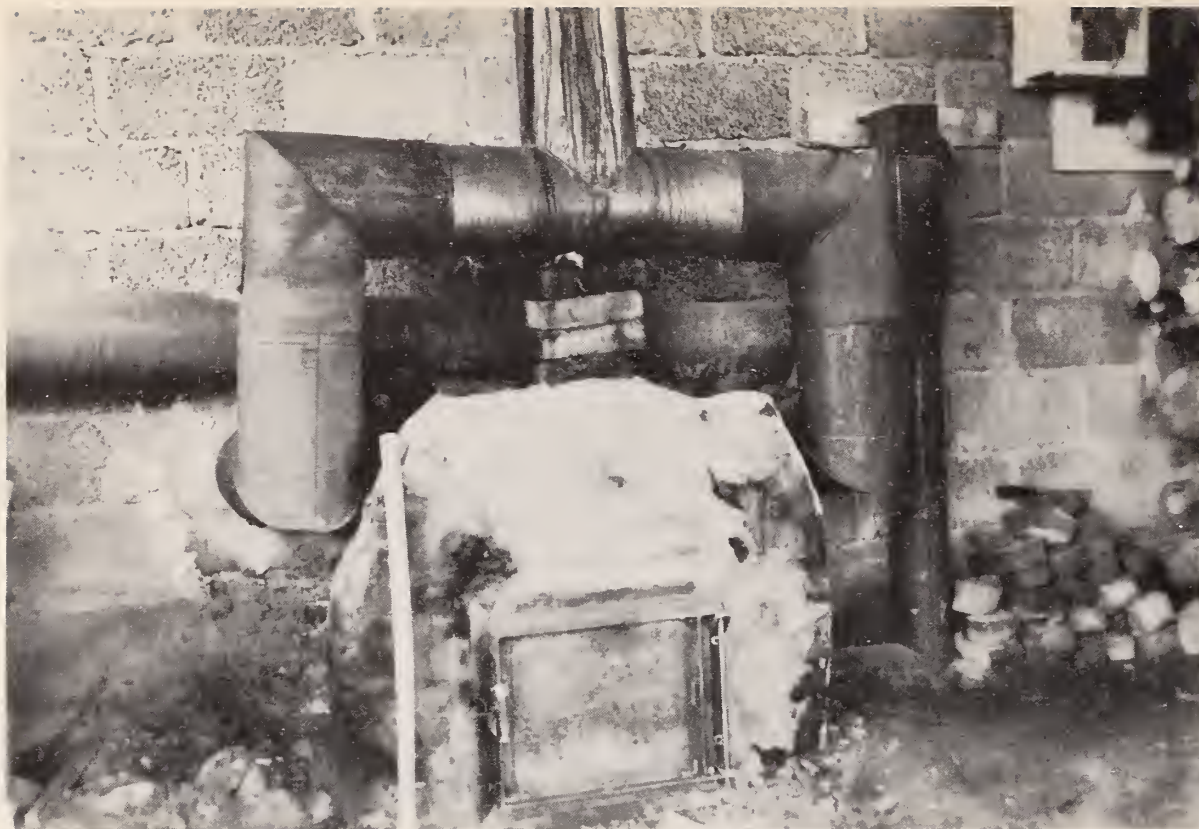


Figure 3.--The first experiment was to operate an old type furnace with a tight door and draft controls on the L shaped air inlet.

The tests made in the summer of 1945 showed that tight doors and simple draft controls on the old open wood furnace will reduce the amount of wood needed to cure a barn of tobacco and will give some temperature control of the barn so that one person need not watch the fire continually. However, this furnace held so little wood that it would burn only for a few hours; it still required more of the farmer's time than a coal stoker or an oil burner. Thus, an entirely new and different type of furnace was planned for the 1946 tobacco-curing season.

The new furnace, designed by the Forest Products Laboratory, was built on a barn at the Tobacco Experiment Station in June, 1946. This furnace was strictly an experimental model to determine whether a large hopper type of furnace could be used which would give continuous high temperatures for 6 to 8 hours.

The 1946 furnace was successful through six cures, using 1.2 cords of oak wood per cure, and conclusively proved that the principle of slow combustion for long periods could be applied in an automatic wood furnace for tobacco barns. Details of furnace construction and temperature control needed further study but the 1946 furnace established the principles that have been used in all subsequent furnaces.

The new furnace was constructed in two main parts--a large hopper or primary combustion chamber on the outside of the barn and a secondary combustion chamber on the inside (fig. 4). This secondary combustion chamber is very much like the old-type wood furnace that extends inside the barn. The entire furnace was built of a single thickness of fire-

brick. On the ground level there was an ash pit about 6 to 8 inches high; above this were grates built of firebricks with four grate openings, merely spaces between the rows of firebricks. Above the grates was the hopper, which extended to the top of the furnace and was large enough to hold about 900 pounds of oak wood. The floor of the hopper sloped on the front side of the furnace so that the firewood rolled to the back, where most of the burning took place. A draft control opening and an ash pit door were on the front of the furnace at the bottom and permitted the entrance of air through the grates and allowed for the removal of ashes. Secondary air inlet pipes on each side of the furnace were about 2 inches in diameter and permitted a continuous flow of air into the secondary combustion chamber. Wood was put in the two side doors, there being no opening in the top of the furnace. In this type of furnace, practically all burning took place in the hopper just over the grate. Air entering the draft control door was preheated to some degree by the sloping brick wall before it passed through the grates where it supported combustion in the lower portion of the hopper. The gases then passed into the secondary combustion chamber, where further burning took place due to additional secondary air supplied. No wood went into the secondary combustion chamber. The gases convected the heat into the flues in the tobacco barn, and the heat was radiated and conducted through the air in the tobacco barn to raise the temperature.

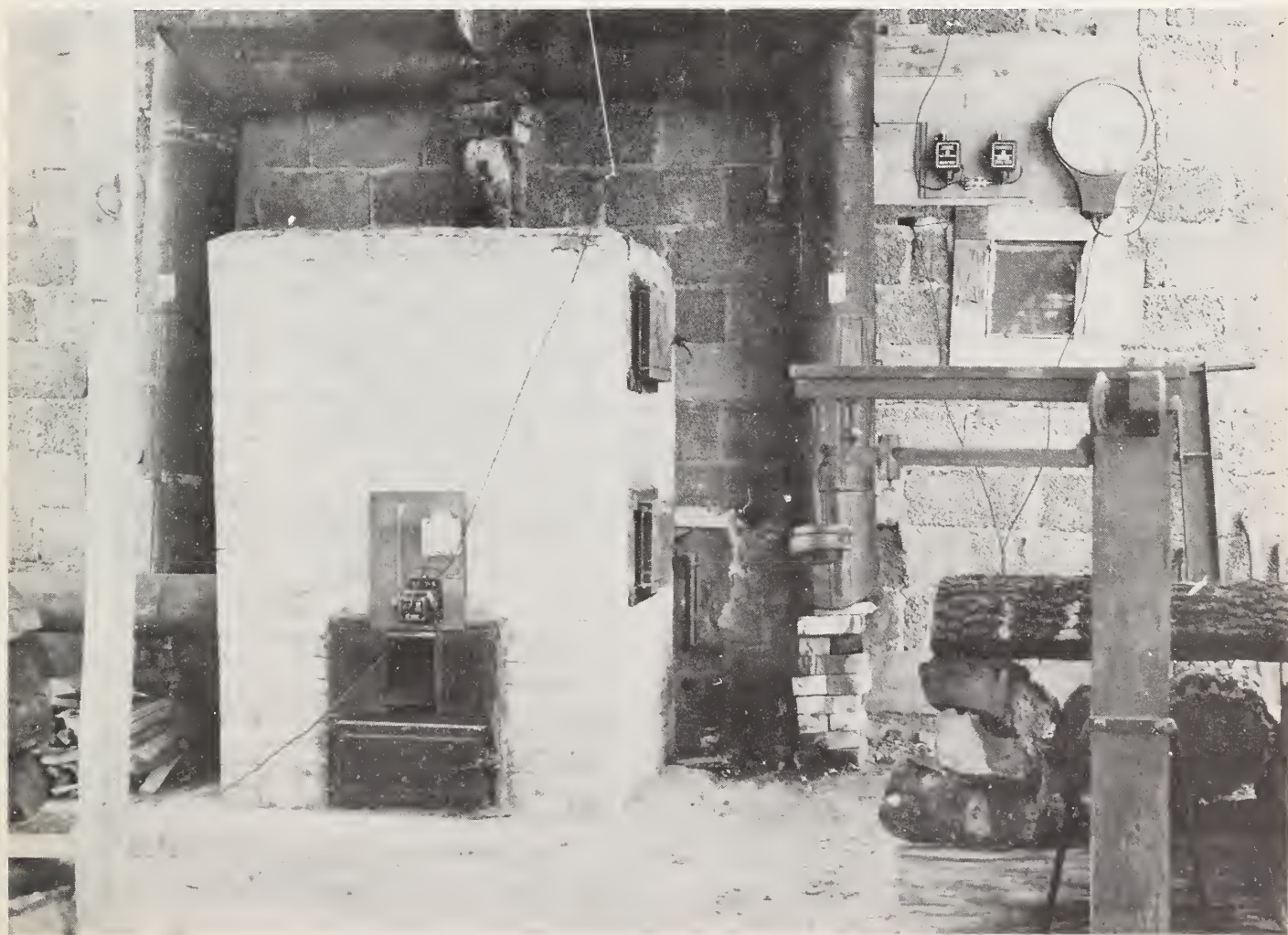


Figure 4.--The 1946 model, only one brick thick and largely outside the barn, was built to establish the principle of slow combustion in a large unit.

Temperature control on this furnace was obtained by use of a thermostat in the barn, which in turn operated a damper motor to open or close the draft control door as necessary to give the desired amount of heat.

Although establishing a principle, the 1946 furnace was too inefficient because it was outside the barn and only one brick thick.

In 1947, a furnace was constructed with most of the unit inside the barn, with the refueling door on the front of the furnace. The furnace construction was quite similar to the 1946 model except that the inside furnace wall was made of firebrick with refractory precast slabs over the arches and the outside wall made with common brick, the two walls being mortared together (fig. 5). Standard thermostat controls operated a draft motor which opened the draft door when the barn called for heat. Two cures made in 1947 used less than a cord of wood each. The furnace operated satisfactorily and gave long periods of burning without attention. The next step was to test it on farms and to see whether it was a durable structure.

In 1948, similar furnaces were built on two private farms and operated under farm conditions (figures 6 and 7); additional cures were also made with the furnace at Oxford. All cures made with these furnaces were satisfactory and the two furnaces on private farms have continued to operate satisfactorily until the last time inspected in 1952. Some objectionable features, however, were discovered during the second year of operation.



Figure 5.--The 1947 furnace, with its refueling door on front, was of double wall thickness and largely inside the barn.



Figure 6.--A straight-walled furnace was built on a private farm in 1948.



Figure 7.--A furnace almost identical with the 1947 model was built on a private farm in 1948. Note rectangular aluminum flues. This furnace operated for several successful cures in 1952.

The large mass of brickwork developed cracks under the severe temperature conditions prevailing in the furnaces. Sometimes these cracks would permit extra air to enter the primary combustion chamber and thereby raise barn temperatures higher than the thermostat settings. These cracks were mortared up after each run, and the bad effects were not serious (fig. 8).

Another disadvantage of the 1948 furnace, and any similar natural draft furnace with two separate flues leading from the furnace, was the heat distribution in the flue system. Whenever one flue became hotter than the other, it would take most of the heat from the furnace, leaving the opposite flue relatively cold. The use of dampers in the flues did not materially change this situation, although the operator could switch the heat back and forth. The net result was uneven temperatures inside the tobacco barn.

Subsequent observations have shown that this condition prevails in most tobacco barns with nearly any type of natural draft furnace, but the operators are seldom aware of this temperature difference, as they operate with only one thermometer in the barn. Nevertheless, the research objective was to produce an automatic wood-burning furnace that would give uniform barn temperatures and long periods of burning, so further development was needed.

In 1949 an experimental furnace was constructed with a dividing wall separating the furnace into two parts except at the fuel door. Here, wood was pushed in on the dividing wall and then turned left or right to fill the hoppers of the two furnaces. The secondary combustion chambers and the flue systems and stacks were completely separate for each furnace.

In operation this furnace performed like the single-type furnace, and when one flue became hot, it drew all the heat from the fire in the other furnace over the partitioning wall. This furnace was abandoned when it became clear that two entirely separate furnaces were necessary to maintain uniform temperatures throughout the barn.

During the same year, two separate and smaller furnaces were constructed in one barn (fig. 9). These furnaces were simplified and constructed with metal grates and doors, vertical walls throughout, and standard refractory slabs to cover the arches. One furnace had the inner firebrick and outer common brick walls mortared together and the other furnace had a 2-inch space between these walls which was filled with a vermiculite insulation material. Each furnace had its own thermostatic control and flue system. Instead of operating the draft doors with a motor, a 1/2-inch-stroke electric solenoid was used on each draft door.

Very satisfactory results were obtained with this dual-type automatic furnace and all the research objectives were met. The insulated furnace stood up better under the intense furnace heat; also, a few other minor refinements and operational details were discovered.

In 1950, the dual-type automatic furnace was partly rebuilt to add the refinements and it was again operated satisfactorily during the curing



Figure 8.--Cracks sometimes developed in brickwork near thimbles or doors and required re-mortaring occasionally.



Figure 9.--The 1949 model dual type automatic wood-burning furnace.

season. A time temperature chart of cure No. 3, 1950, is shown in figure 10. One of the remaining steps necessary before recommending it widely to the tobacco farmer was continued testing for furnace durability and farmer operation. To this end additional cures were made with this furnace in 1951 and 1952.

Also in 1952, two furnaces of this type were constructed on private farms according to plans and supervision furnished by the Forest Service. Farmers operating these furnaces liked the ease of operation and low fuel consumption. Depending on the size of the barn and the quantity and condition of the tobacco, the furnaces cure a barn of tobacco with from $3/4$ to $1-1/4$ cords of wood.

Although this furnace has passed through the experimental stage satisfactorily, it needs to go through the pilot stage in which it would be operated by farmers under farm conditions for several years. Upon the elimination of difficulties which appear in subsequent trials on farms, the unit may be expected to find a place in commercial tobacco production. For the benefit of farmers who are willing to assume the risk of a new-type furnace, complete instructions, including bill of materials and approximate cost are given.

Construction of the Dual-Type Automatic Wood-Burning Furnace

Since the automatic wood-burning furnace is not a cheap installation, it should be built only on a good tight barn with roof ventilators that will control the amount of air passing through the barn.

The first job is to cut two holes in the end of the barn for the furnaces. These holes should be flush with the sides. The finished openings 50 inches wide and 54 inches high should be framed with two 2 x 4's on each side and two 2 x 6's on edge over the top. The foundation or footings of the barn must also be cut out to allow for the foundations of the furnaces (fig. 11).

The slab for the furnace should be 5 inches thick, 46 inches wide, and 82 inches long; it should be 6 to 12 inches inside the side wall, and extend 6 inches beyond the end wall (notice furnace position in figure 12). Where the soil is porous and sandy and drainage is no problem, the top of the slab should be 6 to 8 inches below ground level; otherwise the top of the slab should be kept as low as possible, maintaining drainage. A lumber form should be used for the slab and the ash pit. After the forms are lined up in their proper places and leveled, they should be nailed to stakes to hold them in place. The concrete, made from 1 part cement, 2 parts sand, and 3 parts of gravel, should be troweled smooth and allowed to harden before the forms are removed and the brickwork started (fig. 13).

The furnace consists of a double wall construction with insulating concrete between the inner and outer walls. In general; the inner wall is of pressed firebrick which should be uniform in dimension for thin dipped joints, and the outer wall is of common brick.

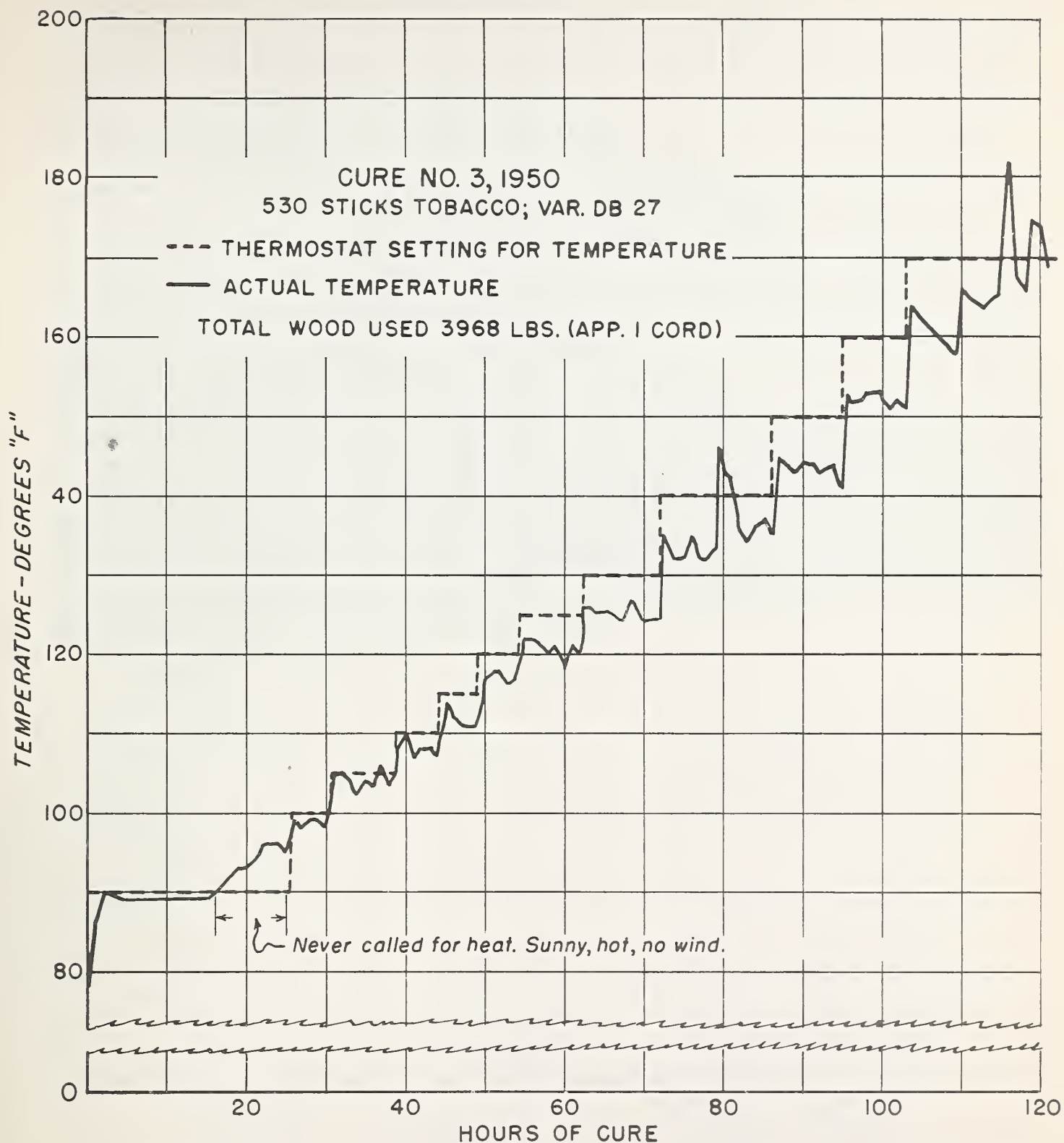


Figure 10.--A time temperature chart for the dual-type automatic wood-burning furnace shows good control. This cure used 3968 pounds of wood (approx. 1 cord).



Figure 11.--Tobacco barn under construction. Two openings in the end of the barn have been cut and framed for the furnaces.

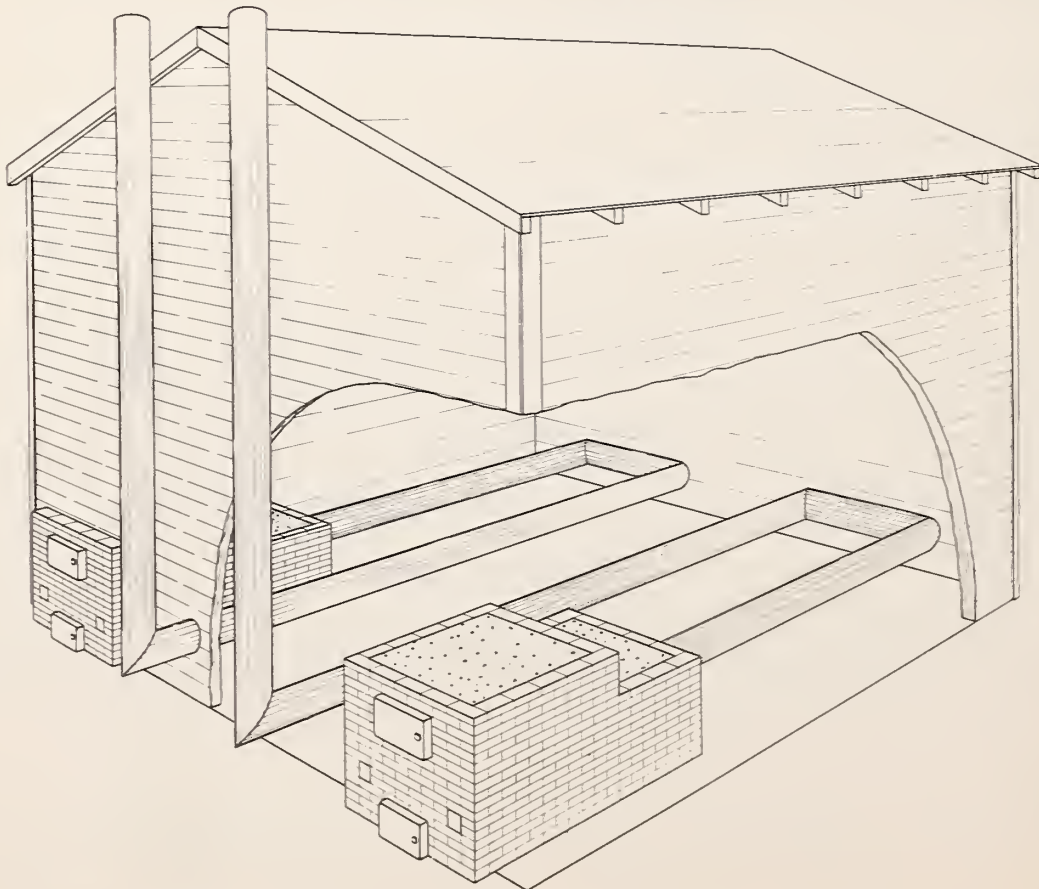


Figure 12.--A cut-away view showing the position of the furnace and flue system with respect to the barn.



Figure 13.--Pouring the concrete slab in the wood form.

Complete drawings of the furnace construction, course by course, are given in Appendix A. These drawings should be followed carefully, especially the dimensions given for the inside walls. The drawings are for the left furnace. This is to have the flue leaving the furnace near to the barn wall to prevent cold down drafts. The right furnace would be constructed with the flue exit offset on the other side.

Careful attention should be given to laying the firebrick. A high temperature refractory cement such as "Setskold" should be used for the firebrick joints. These cements are usually contained in a metal drum and should be mixed in this drum thoroughly before use. A small amount of it is placed in a flat pan; usually it is necessary to thin it with water; and then the firebrick are dipped so that a layer about $1/16$ inch thick adheres to the brick. Naturally the cement must be kept clean from brick chips, etc., if thin joints are to be made. When not being used, the refractory cement should be covered to prevent lumping.

For laying the common brick, use a mixture of 1 part brick mortar and 3 parts of good sand (field sand is not usually satisfactory under high temperature use). The mortar is applied with a trowel, with joints averaging about $1/2$ inch in thickness. The courses of firebrick and common brick must be kept level.

The inner wall can be laid up to and including course 7 before the outer wall of common brick is started. On top of course 2, the lintel for the ash pit door opening must be put in place, the grates on top of course 3 and the thimble on top of course 4 (figures 14 and 15). Sand should be

put in the secondary combustion chamber up to the top of the fourth course of brick. The first four courses of the outer wall can then be completed with the ash pit door frame in place.

The door frames and the flue thimbles should have three layers of wrapping paper on them when they are placed in the wall. This paper will burn away and allow for the difference in expansion between metal and brick. The door frames have threaded holes for the anchor hooks which are mortared in between the two walls.

After the fourth outside layer of brick have been put down, it is time to begin filling the space between the brick walls with insulating cement. Any good vermiculite aggregate (locally sold as Zonolite) is suitable. It should be mixed 5 parts of the vermiculite, 1 part of Portland cement, and 2-1/2 parts of water. Mix the cement and water first and then add the vermiculite. Even though the mix may seem a little dry, it will serve adequately as a filler. The insulating concrete should not be tamped down, but just pressed and dressed down to the top of course 4 with a trowel so that the secondary air ducts can be put in place.



Figure 14.--The lintel for the ash pit door is placed on course 2 and the grates on top course 3.



Figure 15.--After course 4, insulating cement is used to fill spaces between walls, the secondary combustion chamber is filled with sand, and the secondary air ducts are installed.

The outside wall can now be continued up to the eighth course of bricks. After that, the inner wall can be completed. The tenth course of firebricks is put on edge (requiring a number of bricks to be broken in half) in the hopper and at the archway as shown in the drawing of course 10, Appendix A. In the secondary combustion chamber the bricks are laid flat (fig. 16). After course 10 has become firm, the slabs over the secondary combustion chamber can be put in place. More insulating cement can now be added to fill up to the top of course 7 before the work is continued on the outer wall to course 11. More insulating cement is added until it reaches the top of course 11. The fuel-door frame with the cast-iron metal slide is then put in place with a thin cement joint under the frame (fig. 17), and the outer brickwork is continued to course 16. The four hooked screws are mortared in place, and the opening on the sides and top between the outer and inner walls is sealed off with loose brick so that more insulating cement can be added. The slabs over the hopper are now set in place, and the outer wall completed and insulating concrete added and troweled even with the top of the outer wall on both the combustion and hopper sections. Finally, the space between the furnace and the wood wall (opening frame) should be filled with brick or concrete blocks as a safety precaution. Exposed wood should be at least 8 inches from the furnace.

The flues with the hopper type of furnace must be given more slope than with the old type of wood-burning furnace. Where the flues leave the barn they should be at least 10 to 12 inches higher than where they leave



Figure 16.--In the 10th course, half firebricks on edge are used for the inner wall of the primary combustion chamber. (Note: The thimble shown in this photograph is a substitute L flue to form the opening, since the regular straight thimble had not been obtained.

Figure 17.--The fuel door frame, with wrapping paper around it, is cemented in on top of course 11. Notice the metal slide cemented across the brick and under the door frame.



the furnace. Each furnace has its own stack extending above the ridge of the barn. Each stack should have a loose-fitting damper that can be locked in the closed and open positions.

After the furnace has been allowed to stand for several days, a low fire can be built in it to help dry out the unit. The furnace should not carry a hot fire for several weeks, in order to allow the mortar to cure and develop stronger joints.

Operation of the Furnace

The operation of the automatic wood-burning furnace can be dangerous or even unsuccessful if the operator does not understand the procedure. IT IS VERY IMPORTANT THAT THIS SECTION OF THE REPORT BE STUDIED BEFORE THE FURNACE IS OPERATED. The following instructions are very important.

CAUTION: THE DOORS OF THE FURNACE SHOULD NOT BE OPENED EXCEPT WHEN REFUELING BECAUSE:

1. ENTERING AIR CONTAINING OXYGEN WILL IGNITE THE WOOD GASES AND EXPLODE FLAME OUT THE FUEL DOOR. SEE INSTRUCTIONS FOR REFUELING.
2. THE UNCONTROLLED ADDITION OF AIR THROUGH THE FUEL DOOR WILL RAISE THE BARN TEMPERATURE HIGHER THAN THE THERMOSTAT SETTING.

Starting the Fire

Open the ash pit and fuel doors wide. Put paper and kindling wood on top of the grates. Put lighted paper under grates. Leave both doors open until good fire is started. Be sure that flue dampers are open.

Close fuel door and let kindling fire continue until flues are warm and drawing properly.

Open fuel door and fill hopper about half full of wood.

Check thermostats and solenoids to see that they are working properly, set thermostats at 90°F., and close all doors tightly. The solenoid connecting link should be set in the bottom hole for temperatures under 130°F.

The furnace should now hold the temperature at 90°F., for at least 5 or 6 hours.

Refueling at Low Temperatures (90°F. to 110°F.)

When the solenoids keep the draft door open almost constantly, it is an indication that the fuel supply is low. Open the fuel door and stand away from it for a moment. Then inspect the amount of wood and charcoal in the furnace and spread it evenly over the grates with a poker if necessary. Close the fuel door.

Close the dampers in the flues. Turn the thermostat back until the draft door closes. Allow to remain in this position for 5 to 10 minutes while wood is being stacked next to the furnace for refueling. During low temperature stages, use small, crooked, and doty wood if necessary and save the straight, larger pieces for higher temperatures.

Set the thermostat so that draft door again opens. Open the dampers. This is to help prevent flare-back when fuel door is opened.

Open the fuel door and load the wood up to the bottom of the fuel door but not above. Close the fuel door, reset the thermostat to desired temperature. Watch barn temperature for about 10 minutes to see that it does not exceed desired temperature.

Refueling at High Temperatures (110°F. to 170°F.)

When refueling at high temperatures, the same precautions are used as in low temperatures, but the furnace will be much hotter, and care must be taken to do the job quickly and correctly.

It is important not to refuel at high temperatures until necessary. Wait until most of the fuel in the furnace has been consumed and the draft door stays open continuously calling for heat. Usually, this means that the barn temperature will drop 10 to 15 degrees below the thermostat setting, but this will not cause any damage to the tobacco during the higher temperature stages.

Be sure to:

1. Close all doors and dampers 10 minutes before refueling.
2. Have enough large straight wood ready at furnace.
3. Use leather or asbestos gauntlet gloves to prevent burning hands.
4. Have an assistant if possible and use loading device. See figure 18.
5. Open dampers during loading but close immediately after furnace is loaded.
6. Do not reset thermostat or open dampers until 10 minutes after loading.

After a little experience, the operator will learn just about how much wood the furnace consumes in a 3- or 4-hour period during the different stages of curing. He will then arrange to check and load the furnace at breakfast-time, the lunch hour, at suppertime, and at bedtime. These are the times when he ordinarily inspects the tobacco.

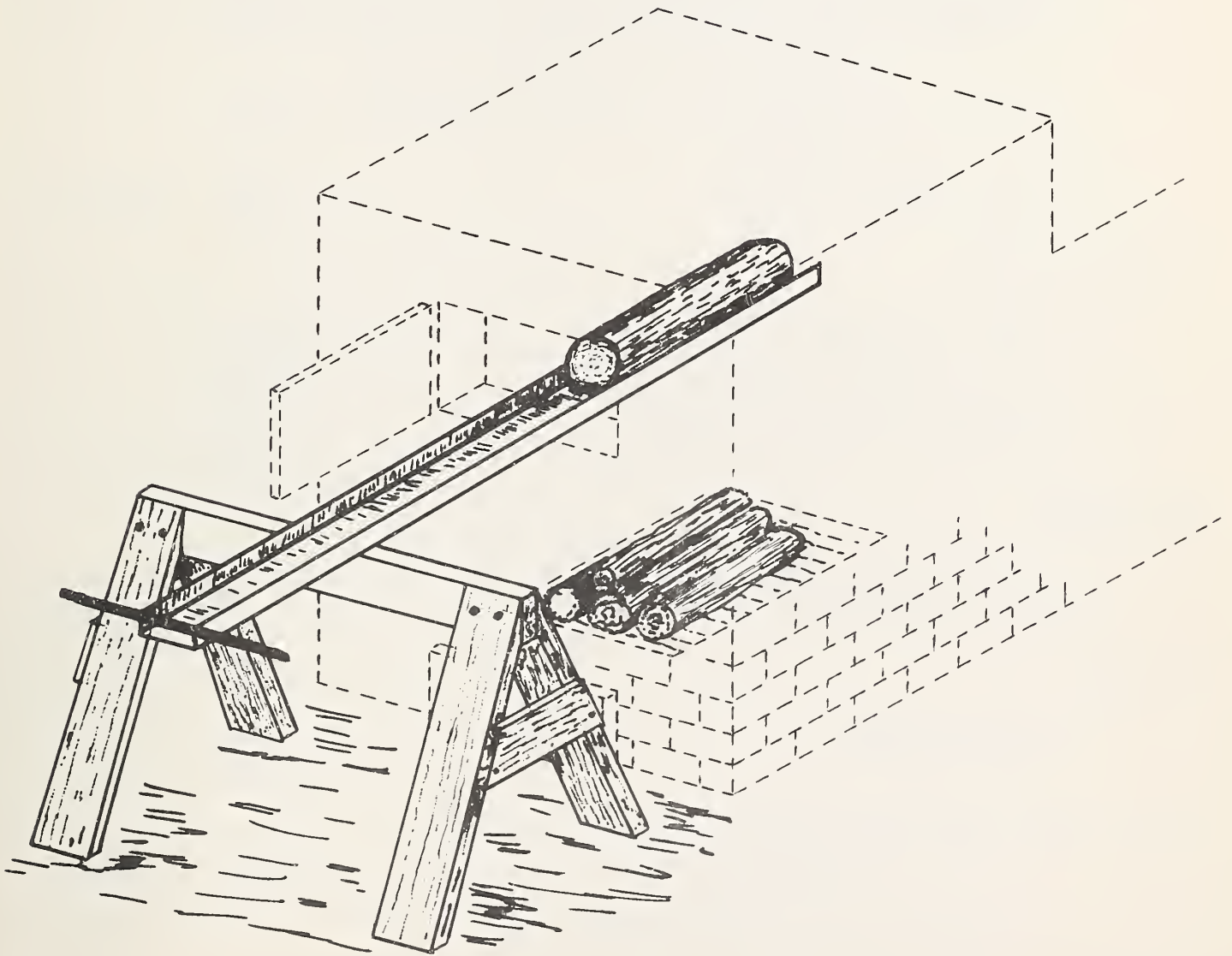


Figure 18.--Round wood is pushed into furnace on a light, 3-inch or 4-inch channel iron. A quick turn of the channel iron with the handle drops the wood to the grates. The handle is a 1-inch iron bar 18 inches long welded to the end of the channel iron.

Cost of the Furnace^{2/}

Bill of Material and Approximate Cost (1952)

	<u>Cost</u>	
<u>Masonry Material</u>		
10 firebrick slabs 3" by 12" by 30" @ \$5.00	\$ 50.00	
530 firebricks 2-1/2" by 4-1/2" by 9" @ \$0.13	68.90	
1150 common bricks @ \$32.00 per M	36.80	
6 bags of brick mortar @ \$1.10	6.60	
11 bags of Portland cement @ \$1.30 .	14.30	
130 pounds of high temperature refractory cement (Setskold or equivalent)	7.60	
8 bags of vermiculite (for concrete aggregate) (Zonolite, etc.)	10.80	
1-1/2 cubic yards of sand	2.50	
3/4 cubic yards of gravel	<u>2.00</u>	\$199.50
<u>Cast Iron Parts</u>		
8 cast iron grates @ \$2.00 each	16.00	
2 fuel door units @ \$14.50 each	29.00	
2 ash pit door units @ \$14.50 each	29.00	
2 lintels for ash pit opening	4.00	
2 slides for fuel door opening	<u>2.00</u>	80.00
<u>Metal Work</u>		
4 secondary air ducts @ \$7.50 each	30.00	
2 flue outlets @ \$2.50 each	<u>5.00</u>	35.00
<u>Controls</u>		
2 thermostats ^{3/}	33.00	
2 solenoids ^{4/}	<u>20.00</u>	53.00
<u>Labor</u> (mason and helper) based on actual cost at 2 installations		
	<u>118.26</u>	<u>118.26</u>
Total Cost		485.76 ^{5/}

^{2/} The costs given are based on actual costs of constructing several furnaces. S. L. Adams Co., Rowland, N. C., is planning to stock all parts for the furnace and the latest costs can be obtained by writing this Company direct.

^{3/} Thermostats can be purchased from United Electric Control, A & Athena Streets, Boston, Mass.

^{4/} The Solenoids (16 KKK, 100A, 1/2" stroke) can be purchased from the Electrical Mfg. Division, National Acme Company, 170 E. 131st Street, Cleveland, Ohio.

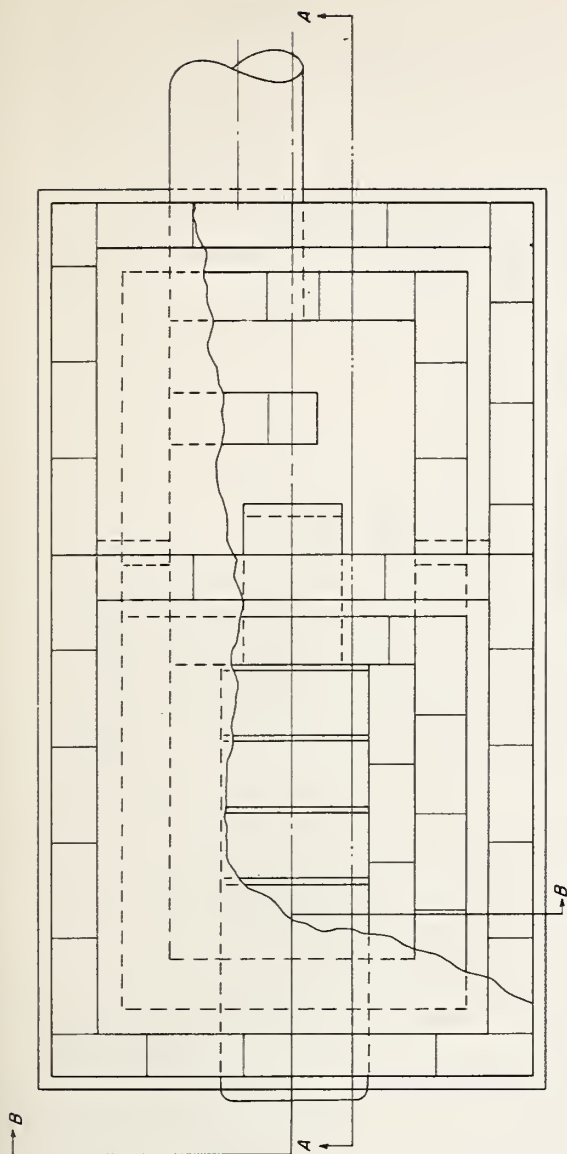
^{5/} Estimates are that this cost can be reduced approximately \$100 by off season work and quantity production of parts.

Conclusions

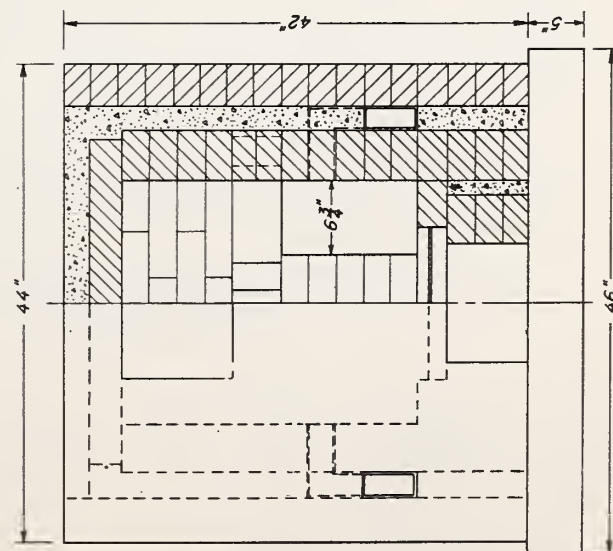
The dual type automatic wood-burning furnace has been experimentally tested and has given satisfactory service in curing tobacco with a fuel savings of as much as 100 percent over other type wood furnaces. Its initial cost is high, around \$400 to \$500. Fuel costs for 6 cures is low, however, near \$60. This compares with a cost of \$150 for oil. It has the further advantage of encouraging farmers to utilize cull wood that would otherwise have little value. Additional field tests by farmers are needed before the furnace can be generally recommended. Further information can be obtained from the Tobacco Experiment Station, Oxford, N. C., or the Southeastern Forest Experiment Station, Asheville, N. C.

APPENDIX A

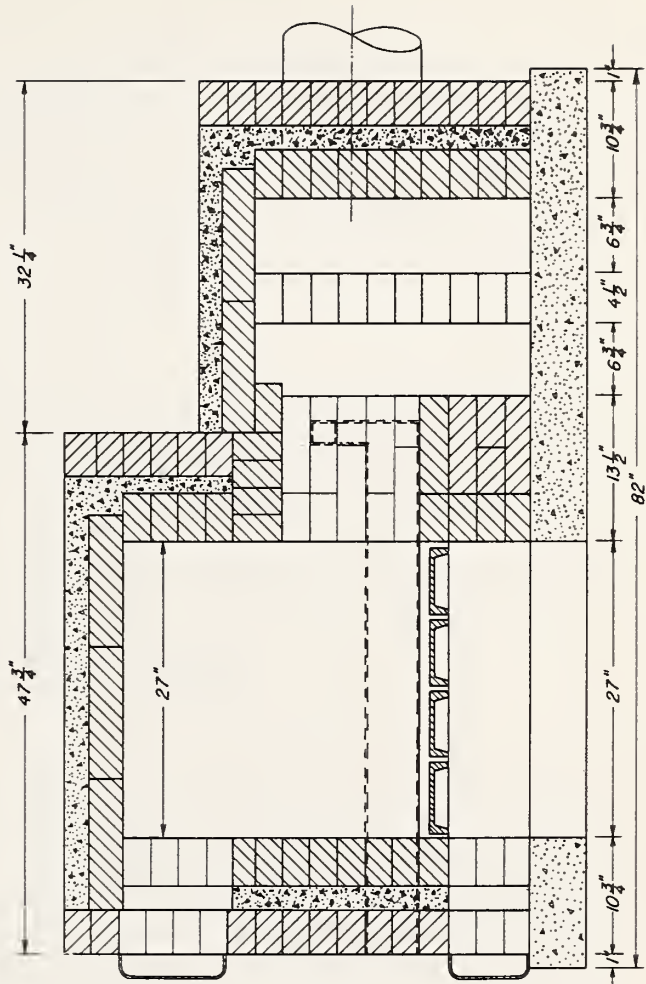
Furnace Construction, Course by Course



VIEW WITH TOP INSULATION AND SLABS PARTLY REMOVED

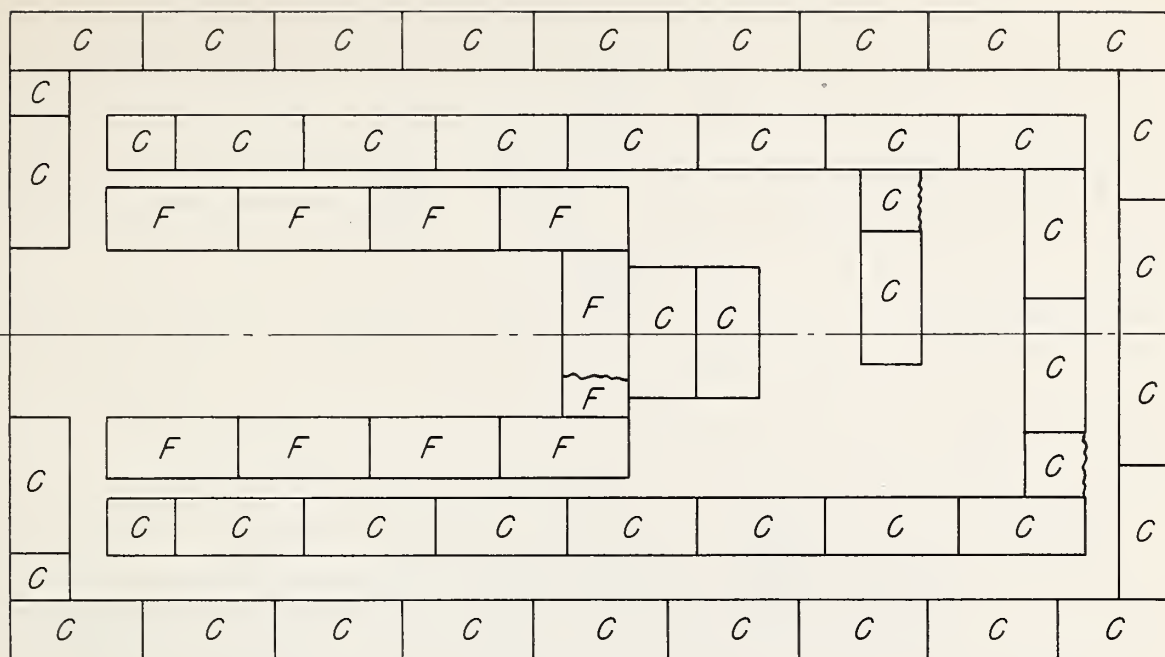


HALF SECTION THROUGH B-B

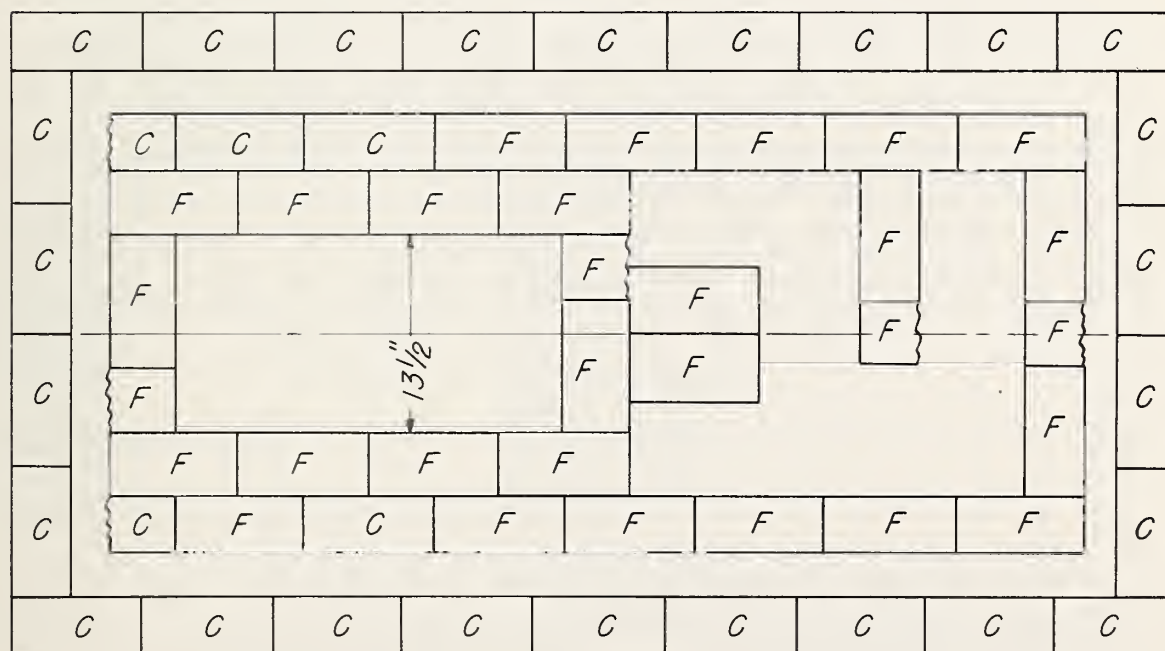


SECTION THROUGH A-A

WOOD BURNING FURNACE
FOR FLUE-CURING TOBACCO
U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
MADISON, WISCONSIN



COURSE 2

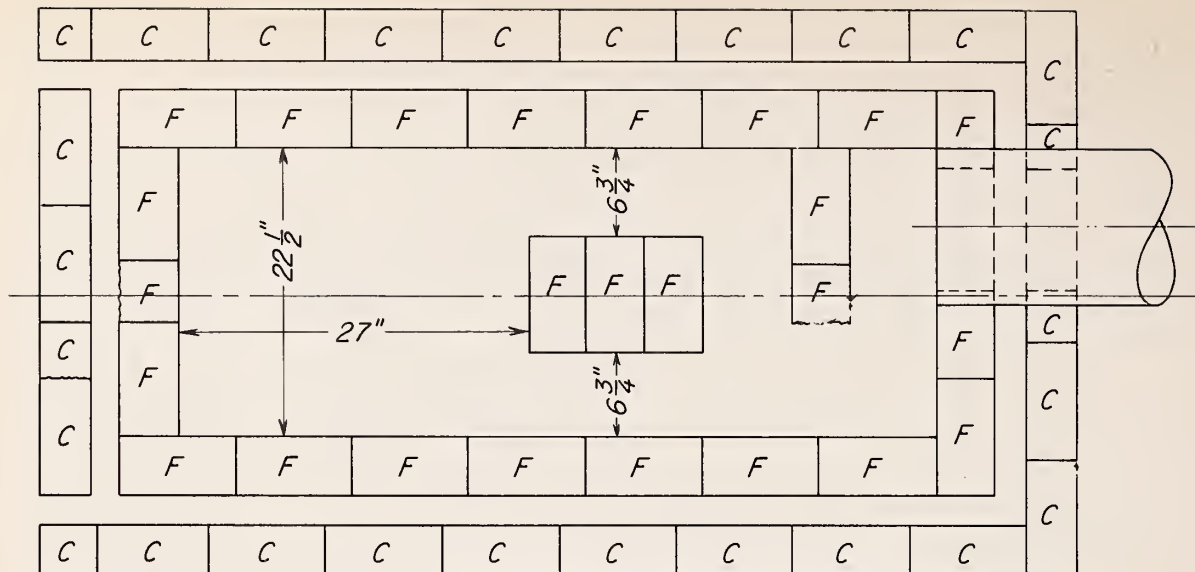


COURSE 4 - PUT GRATES IN PLACE, CONTINUE FIREBRICK WALL TO COURSE 8 INCLUSIVE.

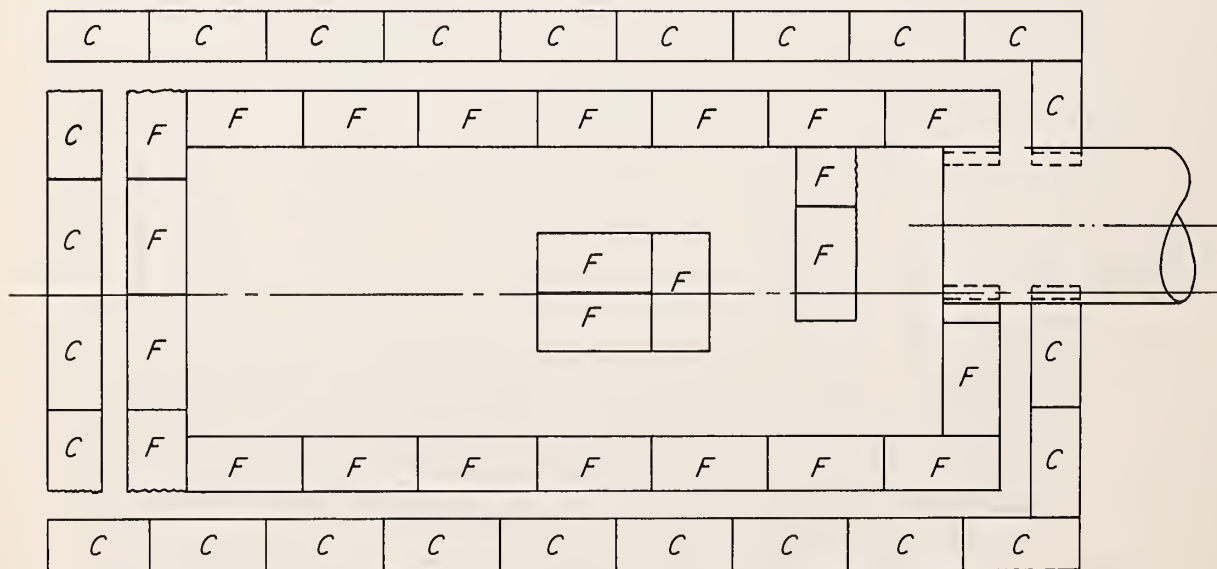
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WOOD BURNING FURNACE
FOR FLUE-CURING TOBACCO

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
MADISON, WISCONSIN



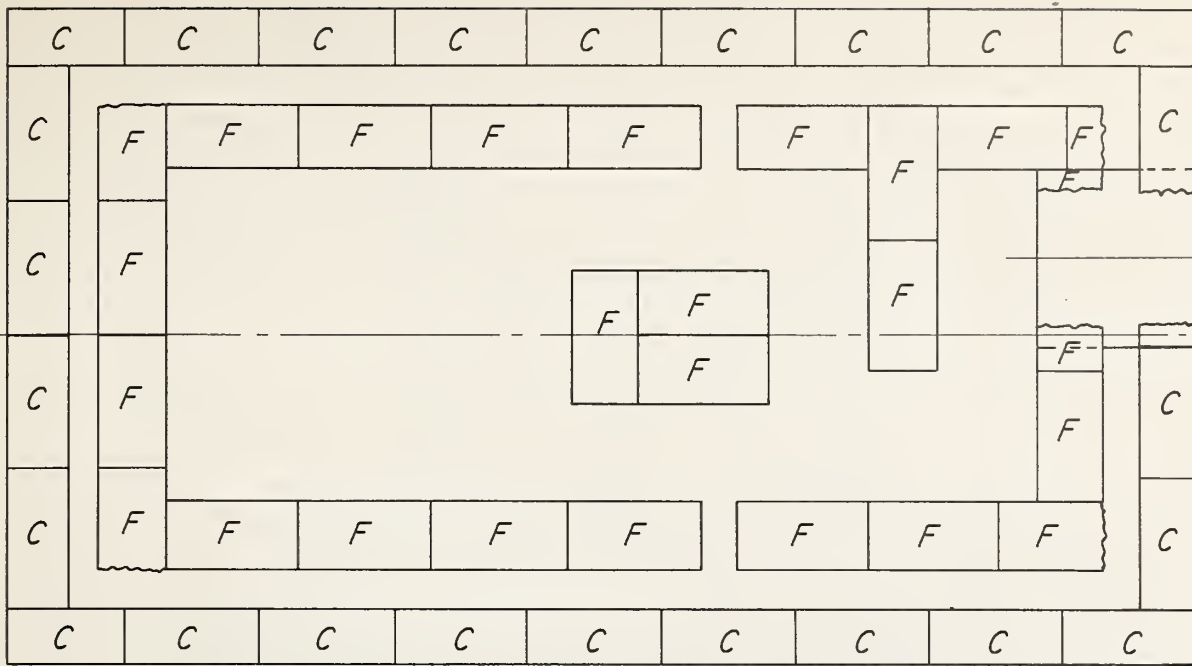
COURSE 5 - PUT THIMBLE IN PLACE, BLOCK OFF ASH-PIT OPENING WITH BOARDS SO THAT SPACE BETWEEN OUTER AND INNER WALL CAN BE FILLED WITH INSULATING CONCRETE TO TOP OF COURSE 4. PUT METAL AIR DUCT IN PLACE.
COURSES 7 & 9 - SAME AS 5 BUT BRIDGE OVER DUCT OPENING.



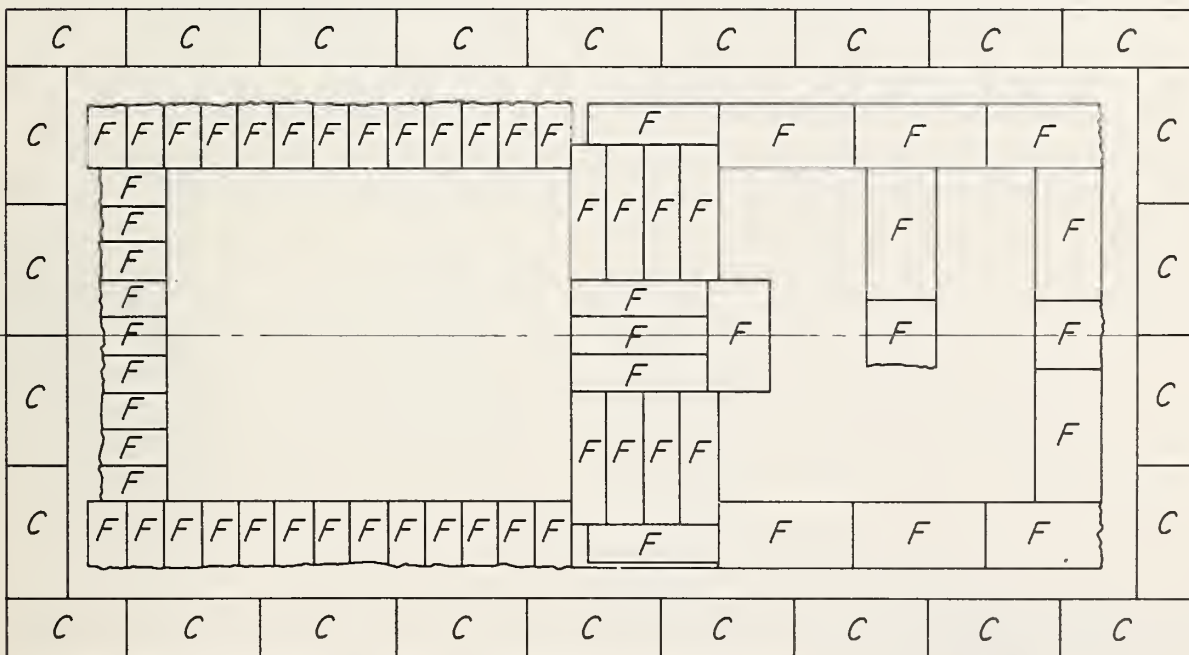
COURSE 6

④

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U. S. DEPARTMENT OF AGRICULTURE
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COURSE 8

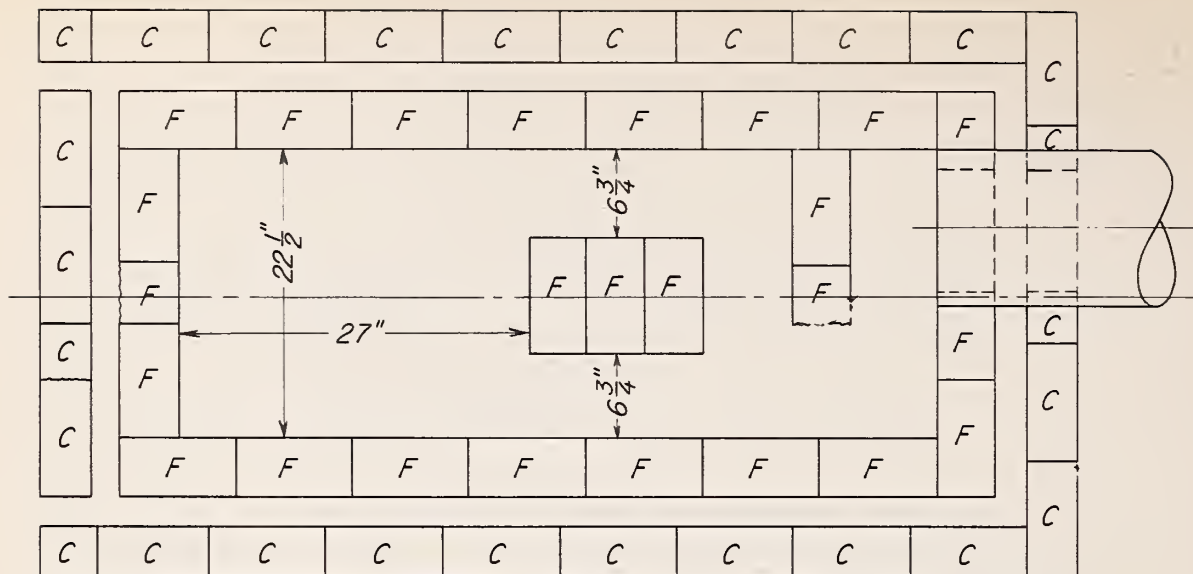


COURSE 10 - FIREBRICK IN HOPPER AND ARCH ON EDGE

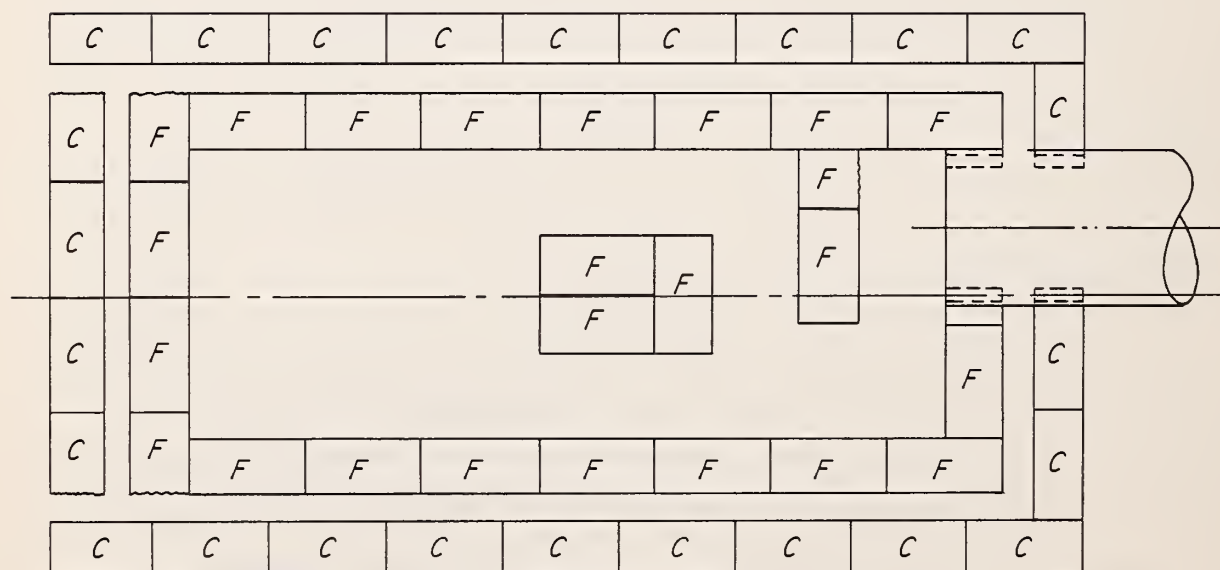
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WOOD BURNING FURNACE
FOR FLUE-CURING TOBACCO
U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
MADISON, WISCONSIN



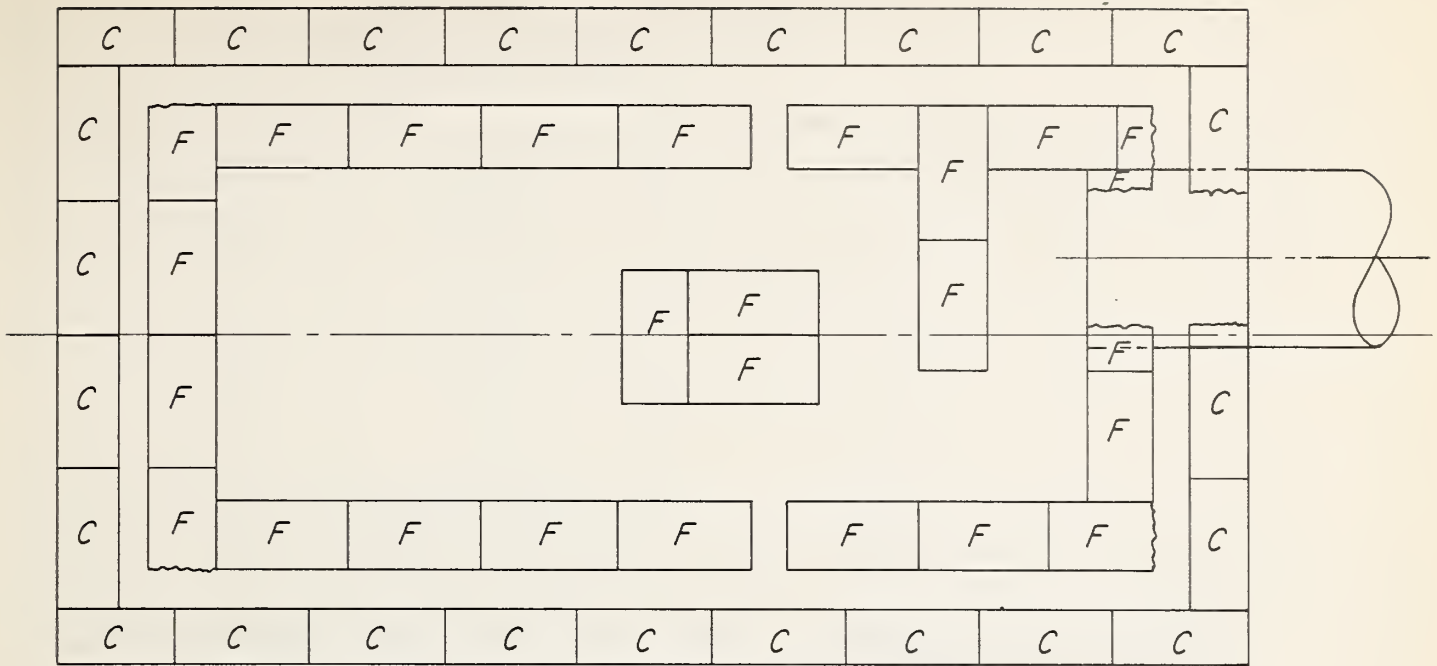
COURSE 5 - PUT THIMBLE IN PLACE, BLOCK OFF ASH-PIT OPENING WITH BOARDS SO THAT SPACE BETWEEN OUTER AND INNER WALL CAN BE FILLED WITH INSULATING CONCRETE TO TOP OF COURSE 4. PUT METAL AIR DUCT IN PLACE. COURSES 7 & 9 - SAME AS 5 BUT BRIDGE OVER DUCT OPENING.



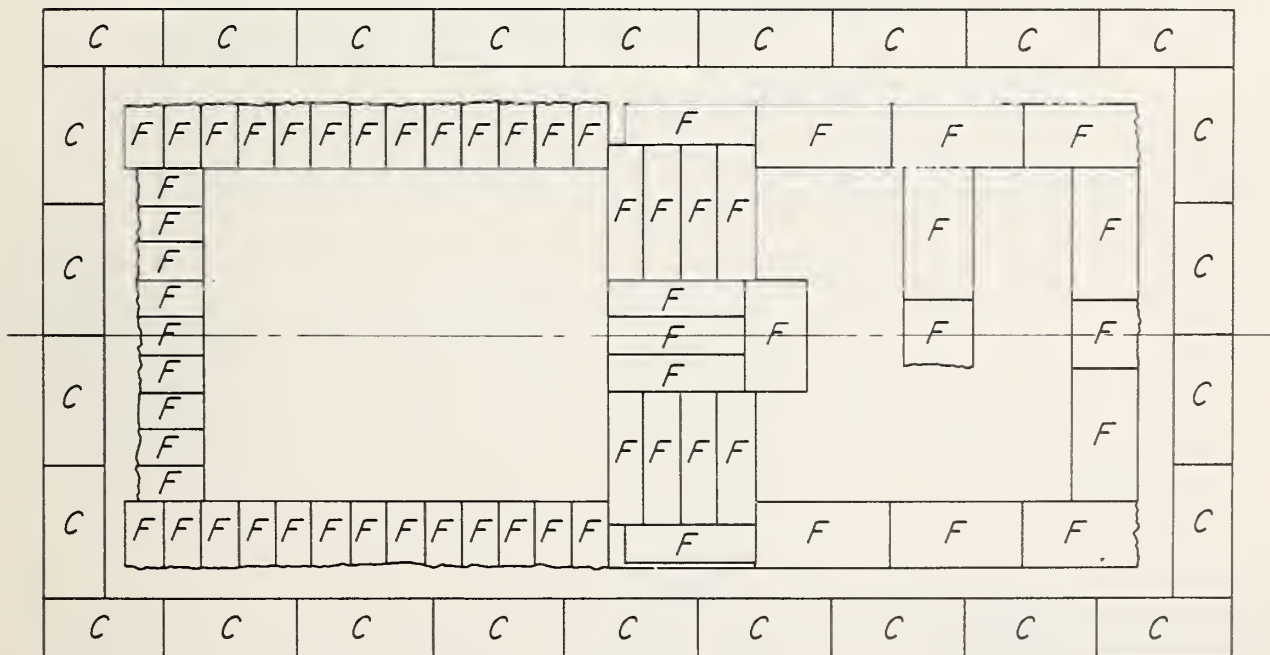
COURSE 6

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FOR FLUE-CURING TOBACCO
U. S. DEPARTMENT OF AGRICULTURE
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FOREST PRODUCTS LABORATORY
MADISON, WISCONSIN



COURSE 8

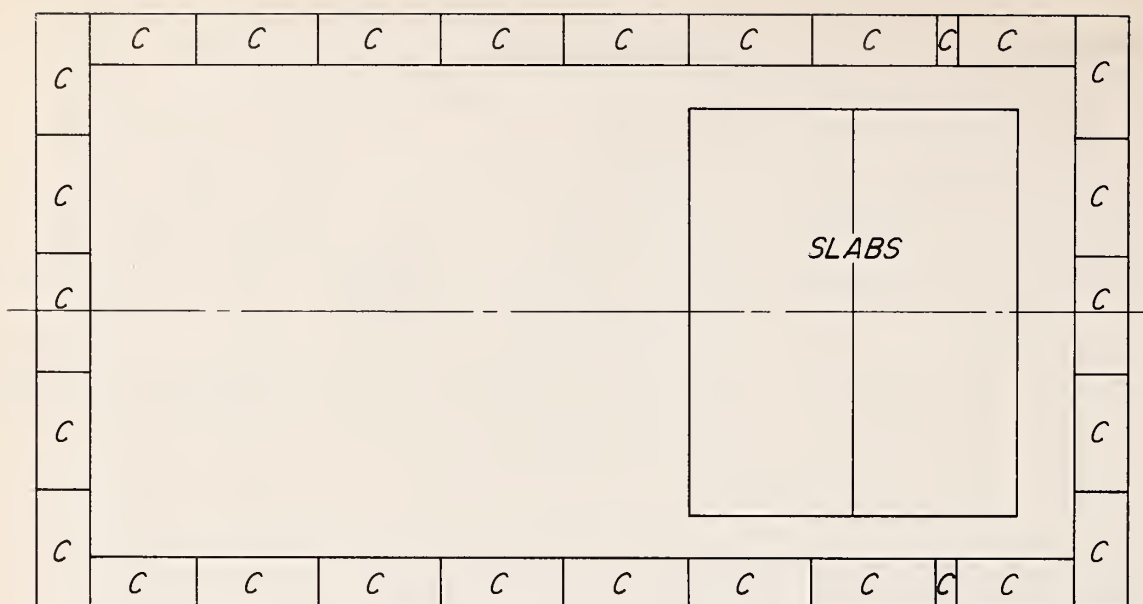


COURSE 10 - FIREBRICK IN HOPPER AND ARCH ON EDGE

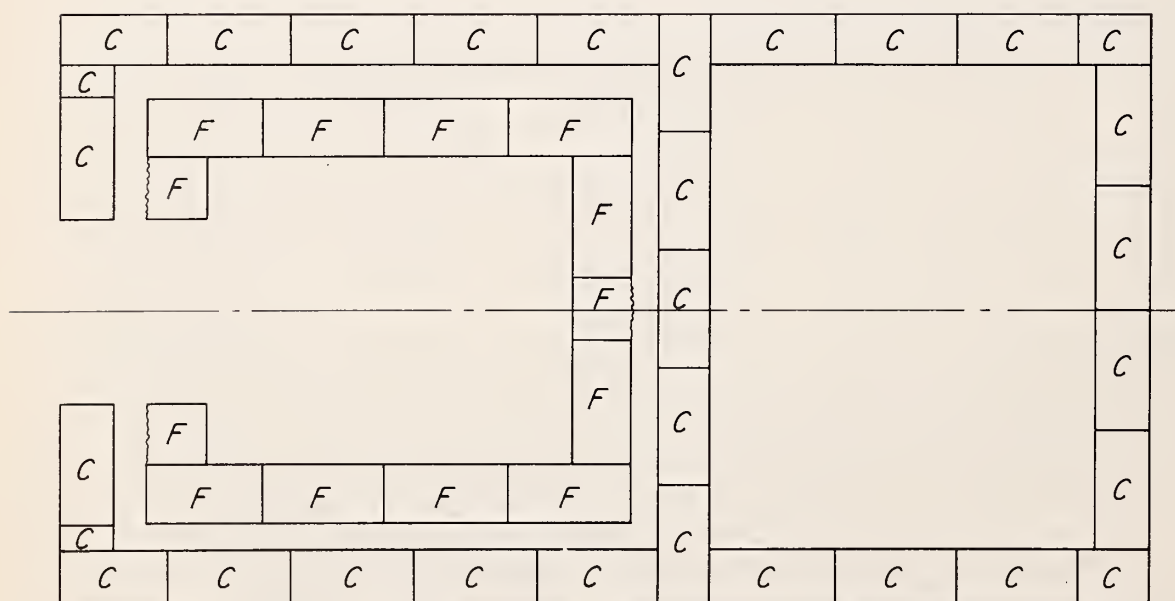
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WOOD BURNING FURNACE
FOR FLUE-CURING TOBACCO
U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
MADISON, WISCONSIN

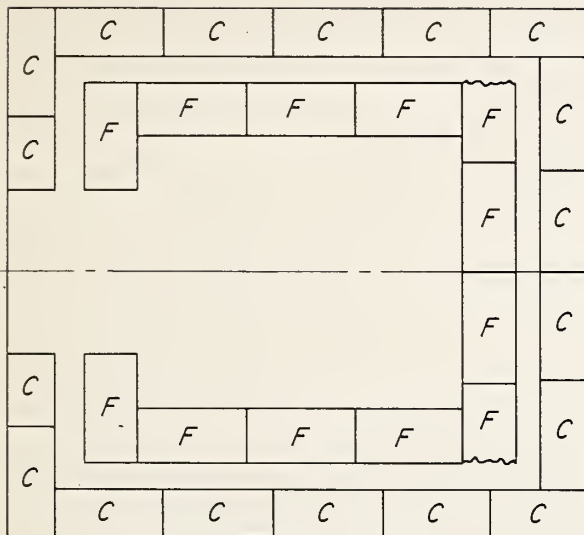


COURSE 11 - PUT SLABS IN PLACE, THEN LAY OUTER WALL
SO OUTER WALL IS ABOUT LEVEL WITH INNER WALL.

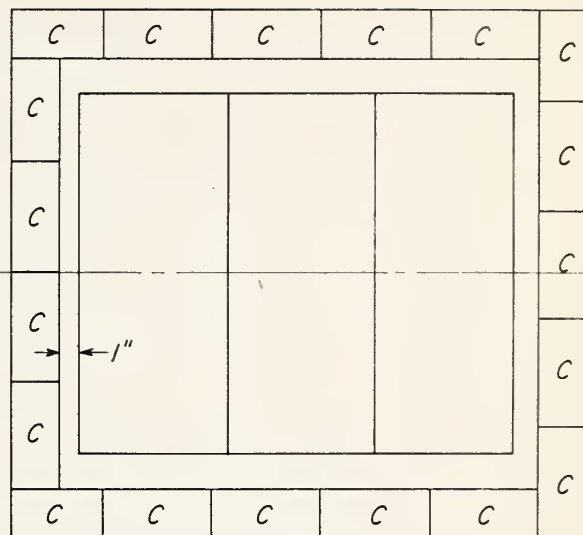


COURSE 12 - PUT DOOR FRAME IN PLACE

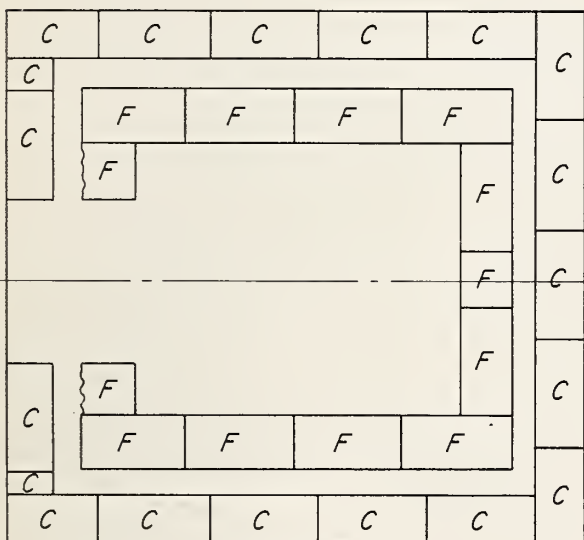
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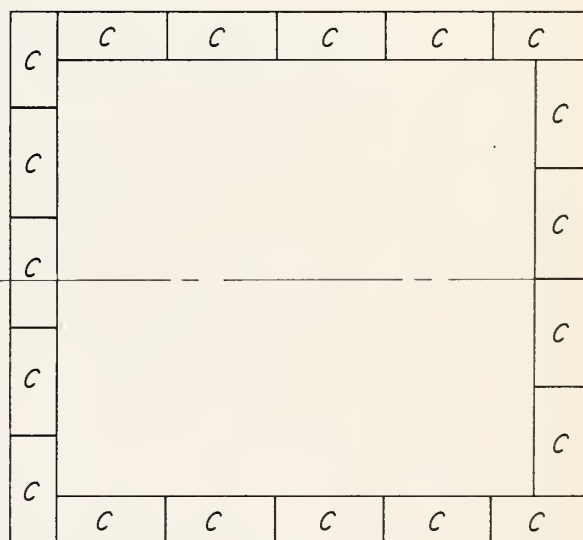
COURSES 13 & 15



COURSE 16



COURSE 14



COURSE 17

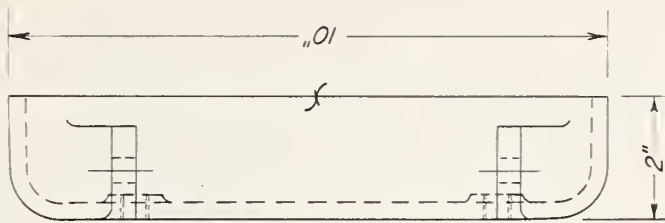
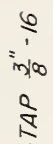
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WOOD BURNING FURNACE
FOR FLUE-CURING TOBACCO
U. S. DEPARTMENT OF AGRICULTURE
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MADISON, WISCONSIN

APPENDIX B

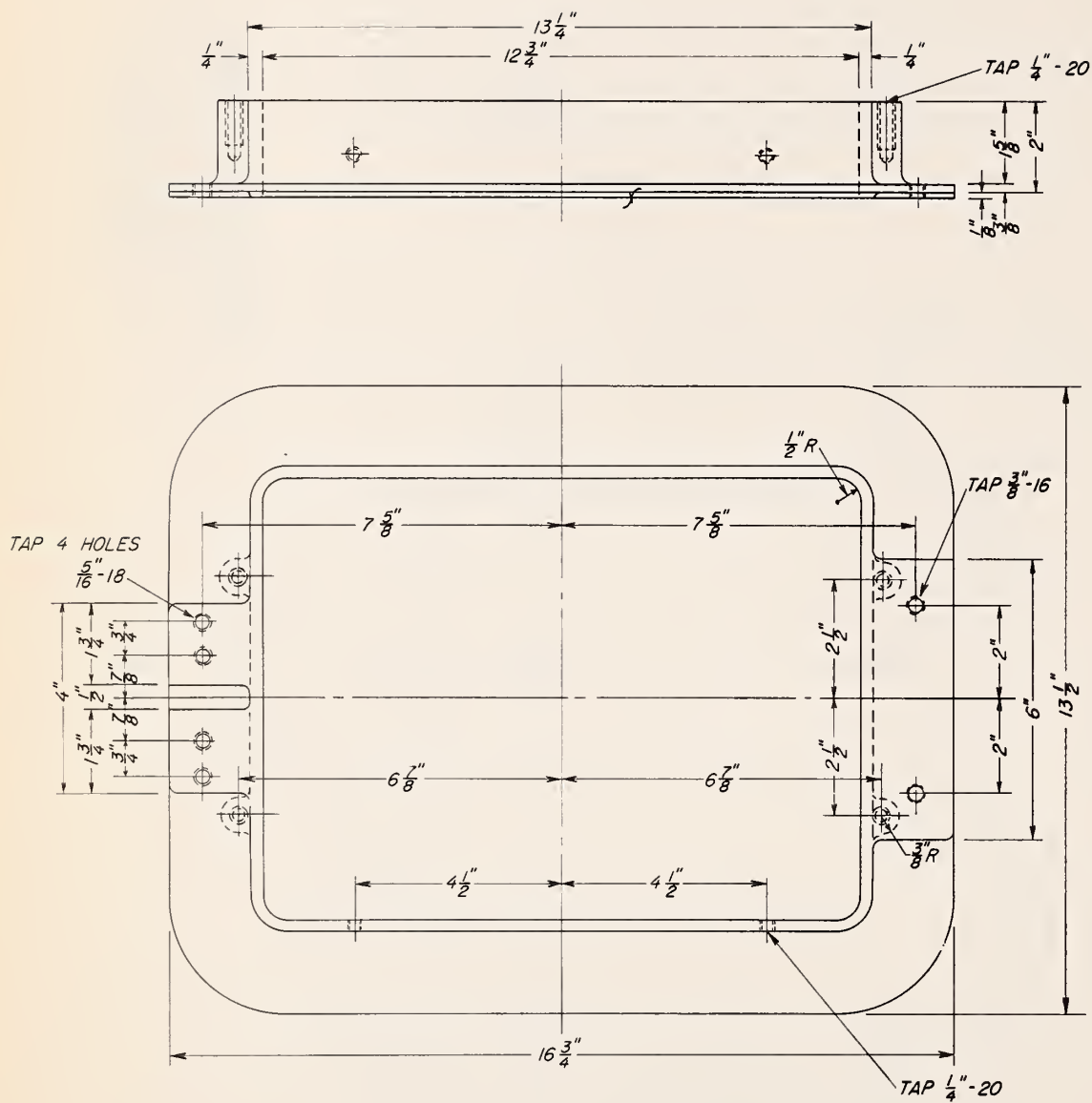
Cast Iron Parts and Metal Work



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WOOD BURNING FURNACE
FOR FLUE-CURING TOBACCO

U. S. DEPARTMENT OF AGRICULTURE
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FOREST PRODUCTS LABORATORY
MADISON, WISCONSIN

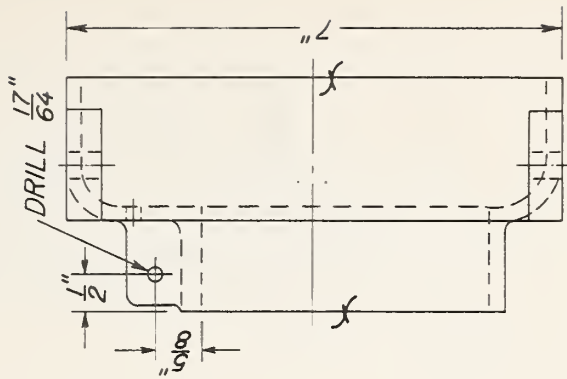
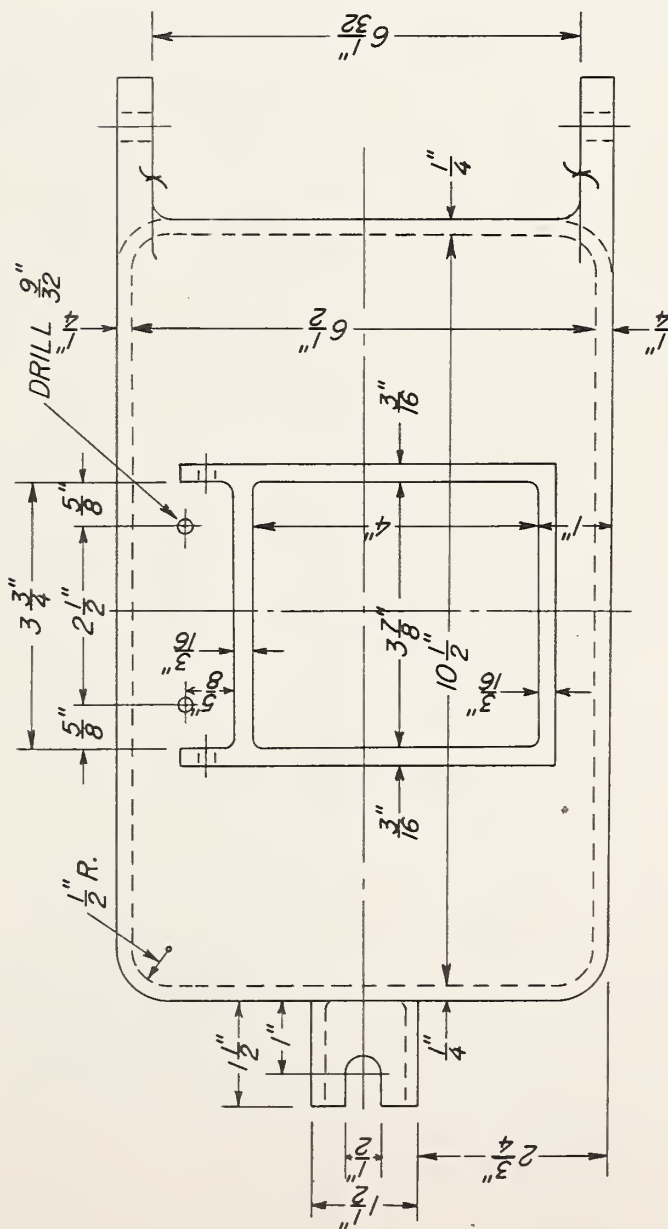
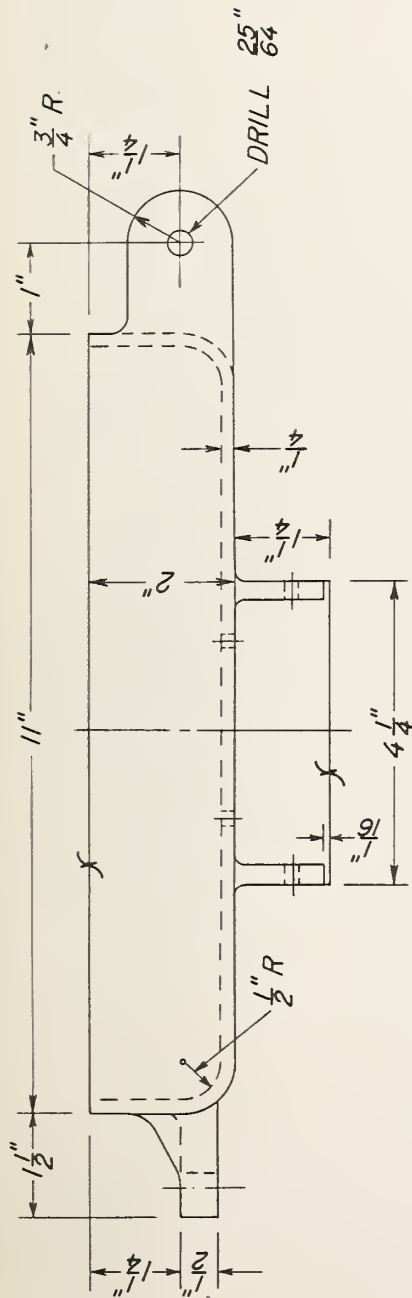


FUEL DOOR FRAME
2 REQ'D - C.I.

Z M 86278 F

9

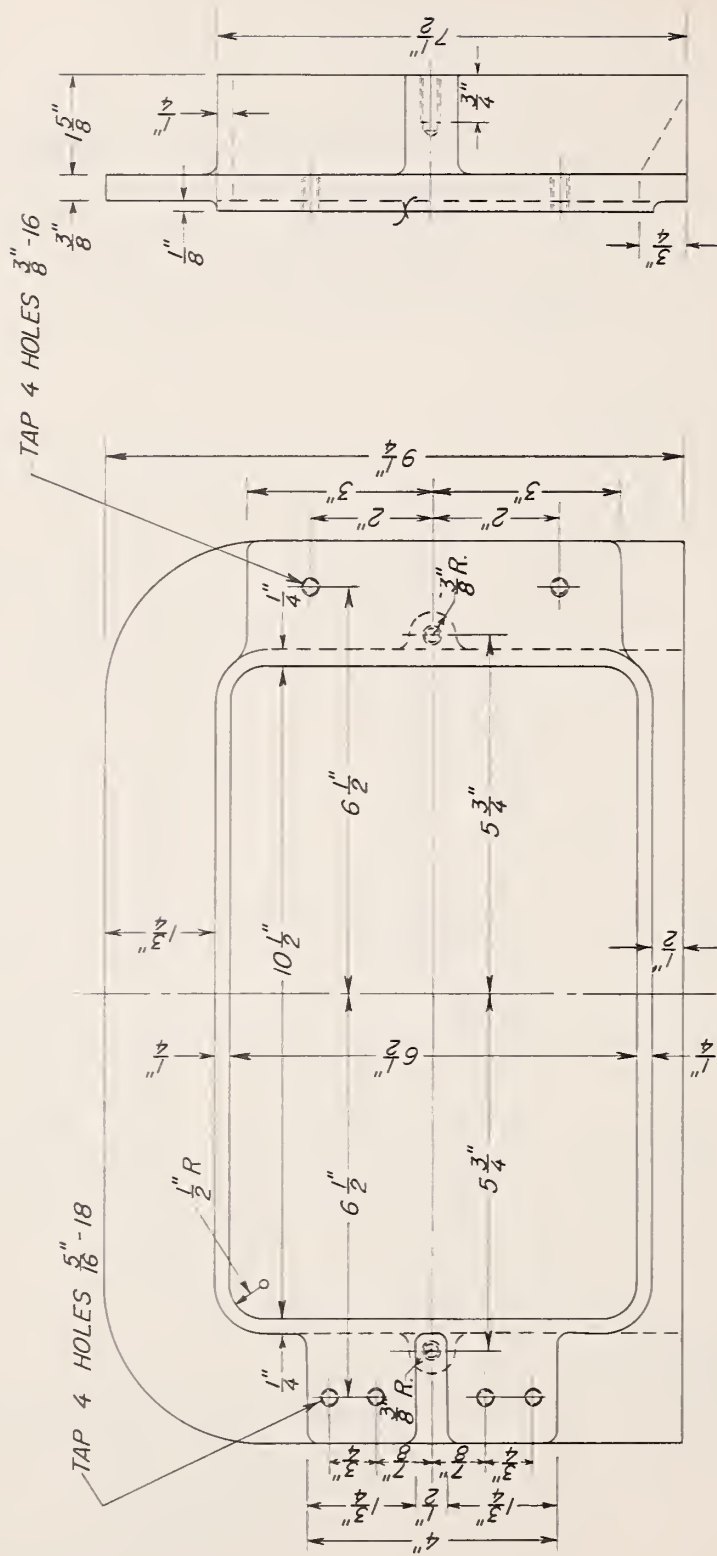
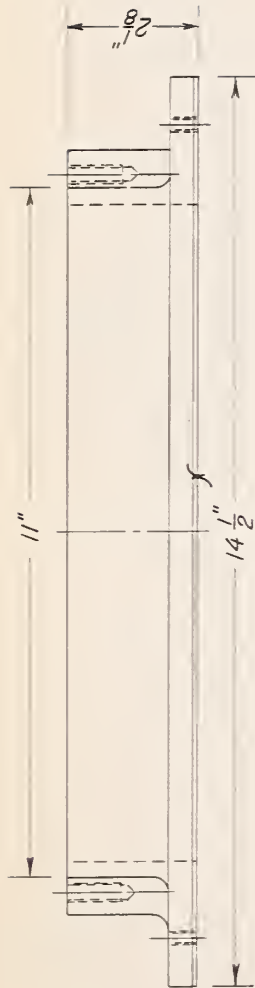
WOOD BURNING FURNACE FOR FLUE-CURING TOBACCO
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ASH-PIT DOOR
2 REQ'D - C.I.

10

WOOD BURNING FURNACE FOR FLUE-CURING TOBACCO
U. S. DEPARTMENT OF AGRICULTURE FOREST SERVICE FOREST PRODUCTS LABORATORY MADISON, WISCONSIN

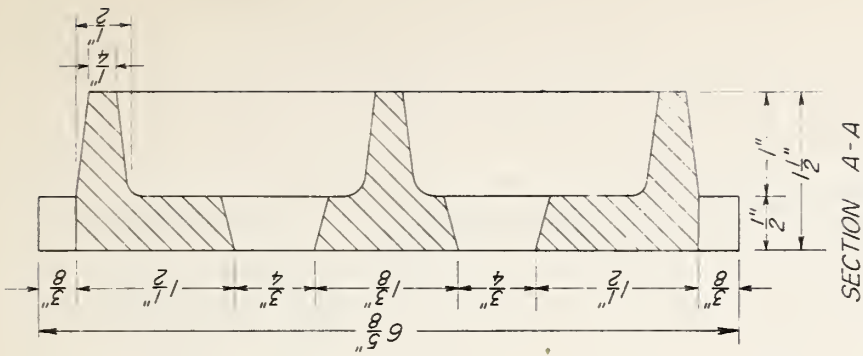
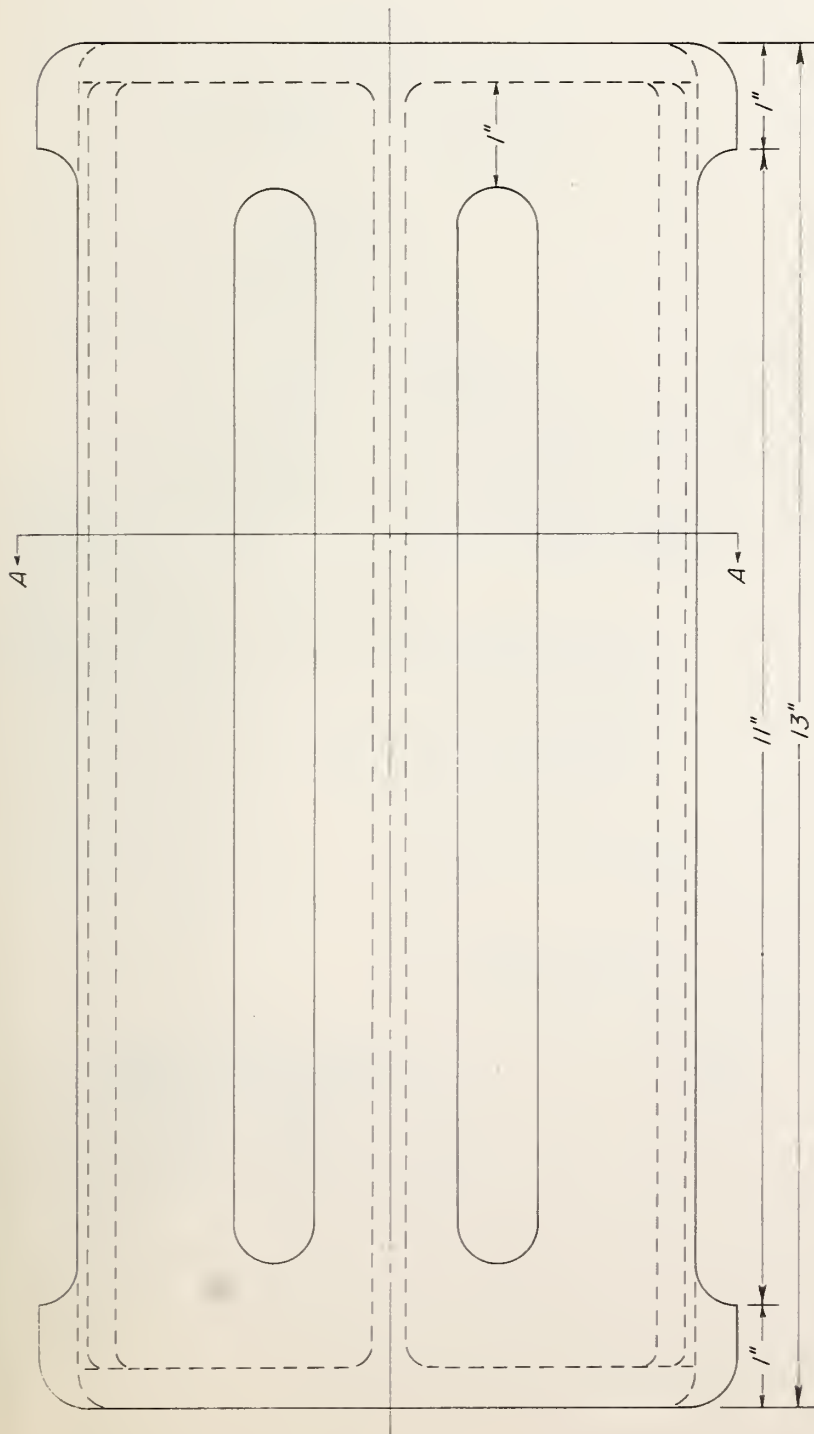


ASH-PIT DOOR FRAME

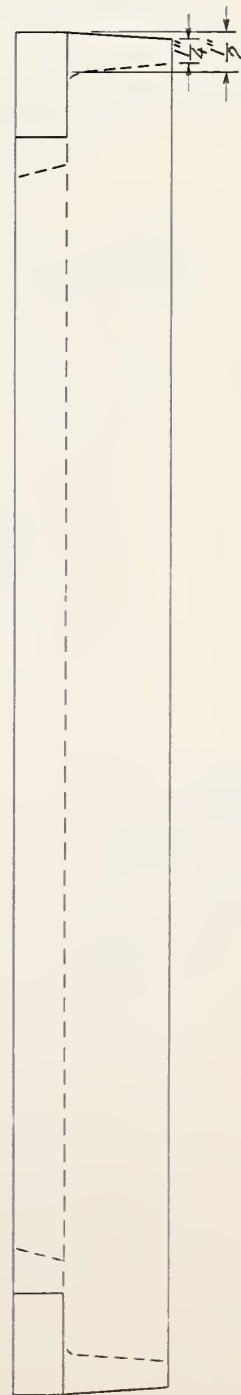
2 REQ'D - C.I.

(11)

WOOD BURNING FURNACE FOR FLUE-CURING TOBACCO
U. S. DEPARTMENT OF AGRICULTURE FOREST SERVICE FOREST PRODUCTS LABORATORY MADISON, WISCONSIN



SECTION A-A

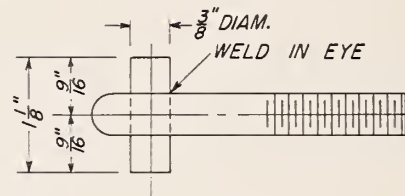
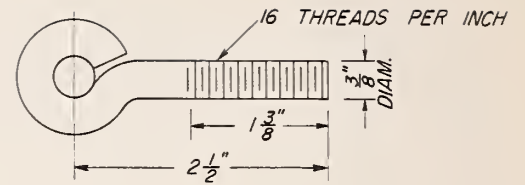
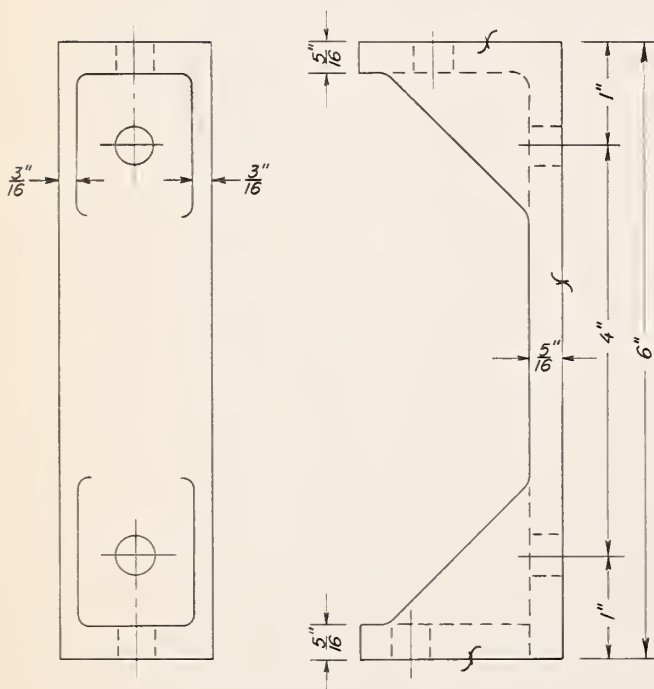
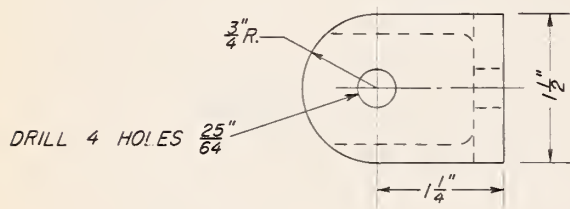
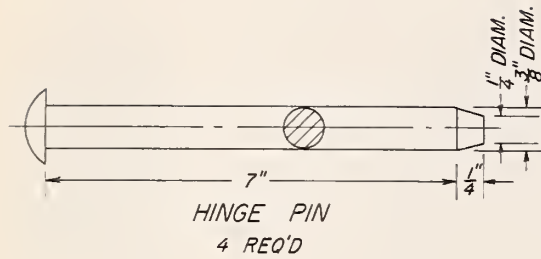


GRATE BARS
8 REQ'D - C.I.

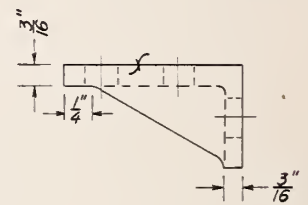
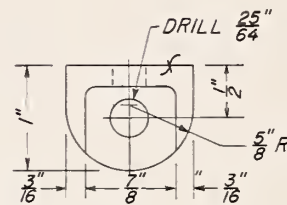
WOOD BURNING FURNACE FOR FLUE-CURING TOBACCO
U. S. DEPARTMENT OF AGRICULTURE FOREST SERVICE FOREST PRODUCTS LABORATORY MADISON, WISCONSIN

12

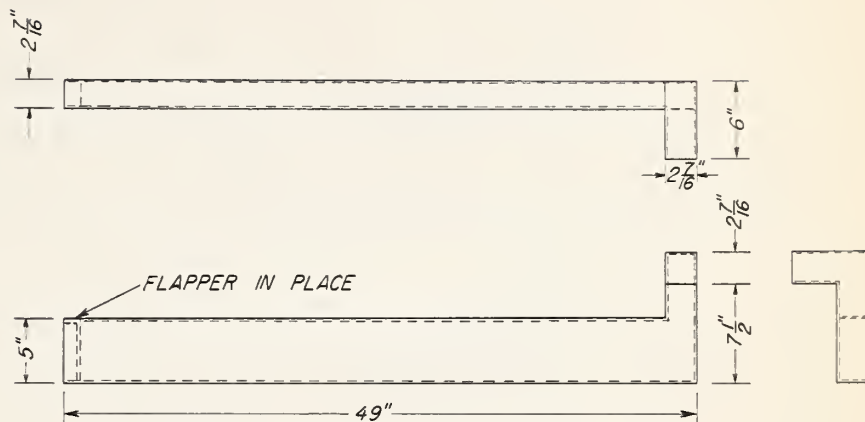
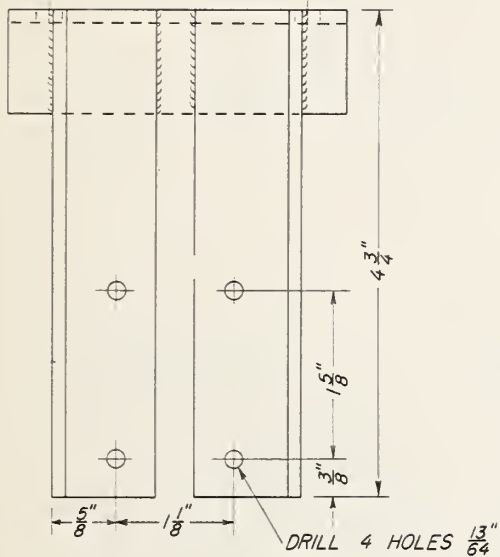
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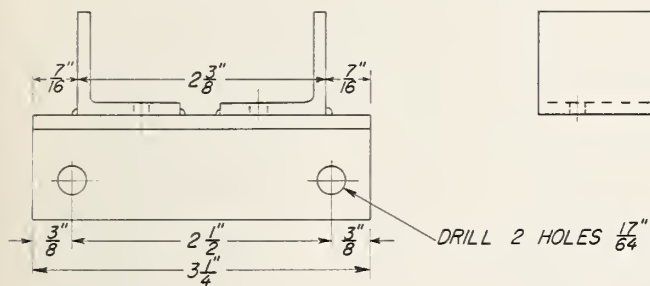
EYEBOLTS
4 REQ'D



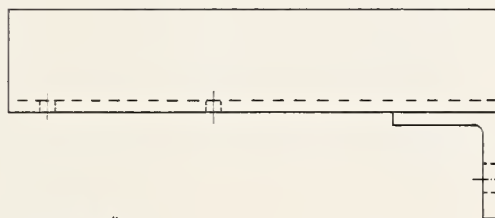
HASP BRACKET
8 REQ'D - C.I.



SECONDARY AIR INLETS
2 RIGHTS AND 2 LEFTS - 22 GA. IRON



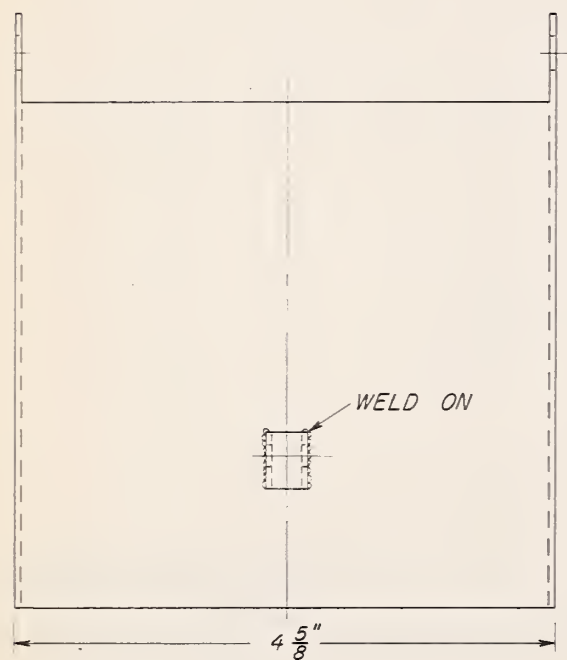
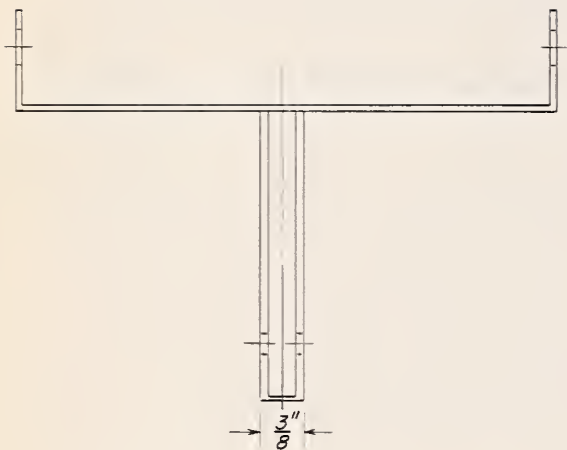
BRACKET FOR SOLENOID
2 REQ'D - 1/8" x 1" x 1" ANGLES



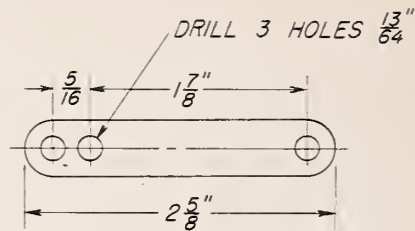
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14

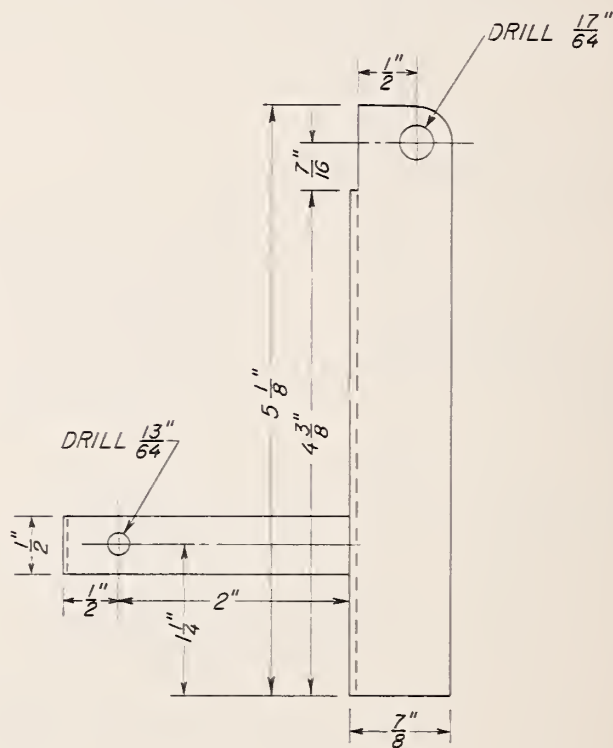
WOOD BURNING FURNACE FOR FLUE-CURING TOBACCO
U. S. DEPARTMENT OF AGRICULTURE FOREST SERVICE FOREST PRODUCTS LABORATORY MADISON, WISCONSIN

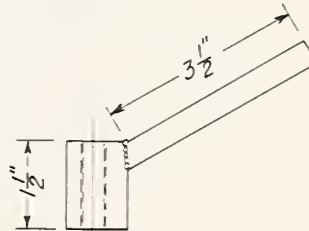
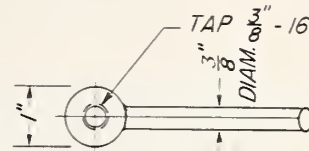
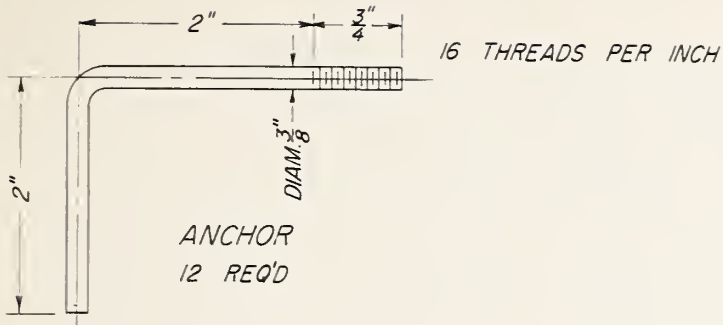


DRAFT DOOR
16 GAGE STEEL - 2 REQ'D
2 - $\frac{1}{4}$ " DIA. x 5" LONG MACHINE BOLTS

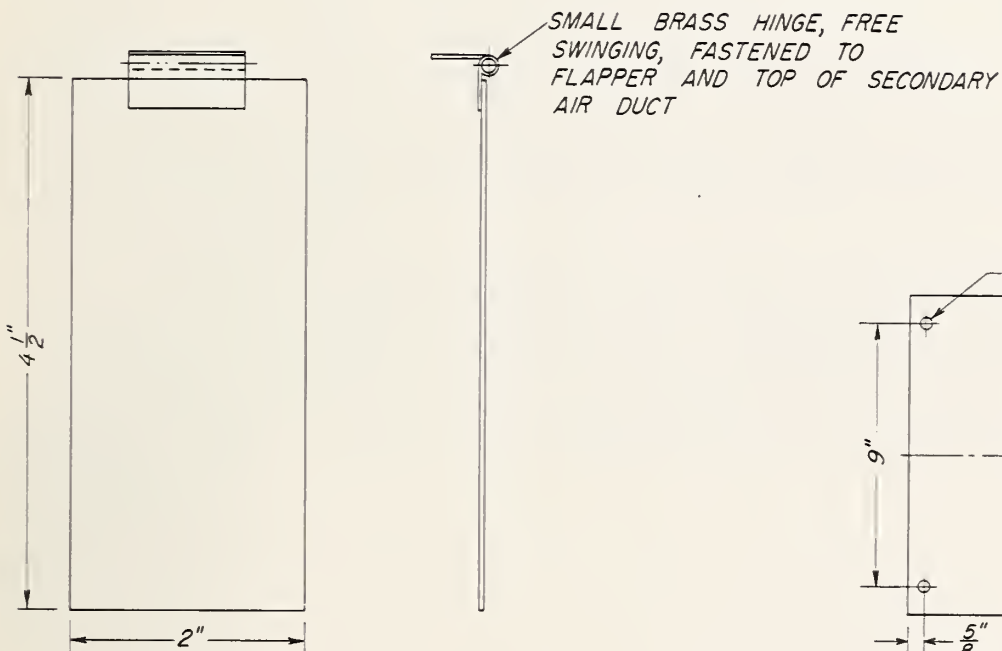


LINKAGE
 $\frac{1}{8}$ " x $\frac{7}{16}$ " STEEL - 2 REQ'D
4 RD. HEAD SCREWS $\frac{3}{16}$ " x $\frac{3}{4}$ " AND 8 BRASS NUTS

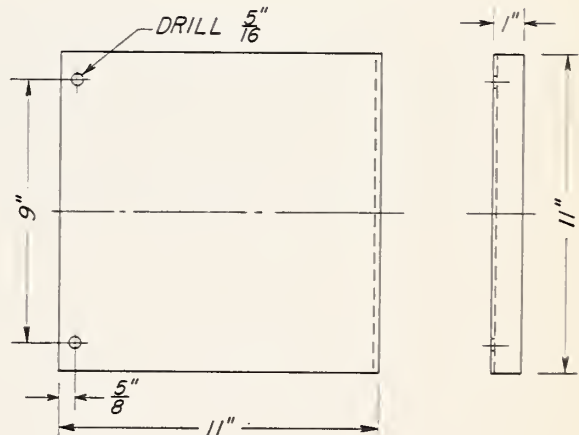




WING NUTS
4 REQ'D



SECONDARY AIR FLAPPER
4 REQ'D - 26 GA. G.I.



FUEL SLIDE
2 REQ'D - 16 GA. STEEL
4 RD. HEAD 1/4" x 5/16" - 20 SCREWS

APPENDIX CSome Suggestions about Wood for the Furnace

Moisture content of wood has a great effect upon its efficiency as fuel. If you use green wood, you need 10 percent more fuel per cure. Therefore, it is to the farmer's advantage to cut his wood in the winter or spring before the curing season and to crib it hogpen fashion for proper seasoning. It is advisable to cut the wood in long lengths in the forest and drag or haul it to a central place where it can be cut to short lengths with a buzz saw and split if stems are more than 8 inches in diameter. For gum and other woods hard to split, a powder wedge will save much labor.

Generally speaking, hardwoods contain more heat per cord than softwoods or pines; many of the hardwoods have little value for other uses. The farmer should use low-grade scrub oak, sweet gum, hickory, and similar trees that have little value as saw timber or pulpwood; they make excellent fuel for curing tobacco. Following are some of the species of wood in the tobacco belt listed in the order of their heat value: hickory, oak, beech, birch, hard maple, locust, pine, sweet gum, sycamore, soft maple, and poplar.

In firing an open-type wood furnace the farmer often wants slightly green wood because it burns slower. Although this may be true in an open furnace, it does not hold true in an efficient furnace where the rate of burning is controlled by the amount of air permitted to get to the fire. In the type of furnace described in this report, the drier the wood the better.

CAUTION:

THE DOORS OF THE FURNACE SHOULD NOT BE OPENED EXCEPT WHEN REFUELING BECAUSE:

1. ENTERING AIR CONTAINING OXYGEN WILL IGNITE THE WOOD GASES AND EXPLODE FLAME OUT THE FUEL DOOR. SEE INSTRUCTIONS FOR REFUELING.
2. THE UNCONTROLLED ADDITION OF AIR THROUGH THE FUEL DOOR WILL RAISE THE BARN TEMPERATURE HIGHER THAN THE THERMOSTAT SETTING.

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